ELEMENTS

OF

PHYSIOLOGY,

FOR THE USE OF STUDENTS,

AND WITH ESPECIAL REFERENCE

TO THE WANTS OF PRACTITIONERS.

BY

RUDOLPH WAGNER, M.D.

PROFESSOR OF COMPARATIVE ANATOMY AND PHYSIOLOGY IN THE UNIVERSITY OF GOTTINGEN, &c. &c.

TRANSLATED FROM THE GERMAN, WITH ADDITIONS,

BY

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PART I.—ON GENERATION.

LONDON:
SHERWOOD, GILBERT, & PIPER, PATERNOSTER ROW.
1841.

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...ILDREN,

...ICINE, &c. &c.

...NOSTER ROW.

LONDON:
GILBERT AND RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.

FIRST DIVISION:

THE

SPECIAL HISTORY OF THE VITAL PROCESSES.

BOOK THE FIRST:

OF GENERATION AND DEVELOPMENT.

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[MICROMETRIC MEASUREMENTS.

The Standard for micrometric measurements very generally followed in Germany, and adopted in this work, is the fraction of a Paris line. In Great Britain, minute objects are usually measured in fractions of an English inch. The Paris inch contains twelve lines, and is longer than the English inch, in the proportion of 1.06575 to 1.00000; that is, the Paris inch is equal to 1 and $\frac{1}{15}$th of an inch English very nearly. Assuming this ratio to be sufficiently correct for all practical purposes, it is easy to convert fractions of a French line into fractions of an English inch, by multiplying the denominator of the former by the number 11.25. R. W.]

ELEMENTS OF PHYSIOLOGY.

BOOK THE FIRST.

OF GENERATION AND DEVELOPMENT.

SECTION THE FIRST.

OF GENERATION.

THE SUBJECT AND MODE OF TREATMENT.

§ 1. In the act of GENERATION two different matters or elements are brought to exert an influence upon each other. These elements are formed and separated from the blood in the germ-preparing organs of the male and female, when they have attained their maturity. The male generative element is called SEMEN (SPERMA), *seed;* the female, OVUM, *egg*. As the effect of an intimate conjunction of both of these elements, the EMBRYO is evolved, which proceeds to its ulterior development either within or without the body of the mother. The act of generation is complete, when the maternal generative element has been consumed or exhausted, and the various organs of the embryo are so far developed, that it is fitted to assume an independent existence, and to take nourishment from without. The DEVELOPMENT OF THE EMBRYO would consequently appear to be but a second stage or division of the generative act.

§ 2. In our exposition of the elements which enter into the generative act, we shall follow at once an analytic and a synthetic method. We shall begin with an analysis of the germ-preparing organs and generative matter in the male, next investigate the primary formations in the germ-preparing organs of the female, and

wind up these anatomico-physiological notices with a general account of the forms of the sexual system, in the course of which the usual amount of knowledge of human anatomy will be presumed. We shall then proceed to consider the phenomena that accompany the encounter of the two matters essential to generation, particularly describing the general occurrences of the first moment of the generative act, which afford an explanation of some questions connected with the subject[1].

CHAPTER I.

ANALYSIS OF THE GERM-PREPARING SEXUAL ORGANS, AND THEIR PRODUCTS.—MICROSCOPIC ANALYSIS OF THE SPERMATIC FLUID.

§ 3. THE SPERMATIC FLUID (*sperma, semen*), which is secreted in the testicles of all male animals capable of reproduction, is of thick consistency and a whitish colour. This fluid is obtained for analysis in greatest purity, and most completely formed, when a drop of it is taken directly from the epididymis or vas deferens and transferred to the field of the microscope. Care must be taken to choose the

[1] The majority of the older works on generation have, at the present day, merely an historical value. They mostly consist of pure speculations, without any foundation in fact or observation: these works will be referred to by-and-by in our History of Physiology, and also in the different sections of the present book. The most remarkable among the older works is, undoubtedly, that of Harvey, *Exercitationes de Generatione Animalium*, Lond. 1651, in 4to. The writings of *Regner de Graaf*, entitled, *De Virorum Organis generationi inservientibus*, Lugd. Batav. 1668, in 8vo, and *De Mulierum Organis*, &c. ib. 1672, are also of great importance. Copious summaries of all the observations of the older writers may be found in Haller's *Elementa Physiologiæ*, vol. vii. p. 410. 1765. Among the writings of more recent date which treat of the subject of generation generally, we must particularly refer to that of Spallanzani, *Expériences sur la Génération par Senebier*, Genève, 1783, translated into German, by Michaelis, Leipz. 1786; [and into the English, in *Tracts on the Natural History of Animals and Vegetables*, by Dalyell, Edin. 1803;] to that of Oken, *die Zeugung*, Bamberg and Würzburg, 1805; of Prevost and Dumas, *Nouvelle Théorie de la Génération, Annales des Sciences Nat.* tom. i. ii. and vi.; of Burdach, *Physiologie*, B. i. (second edition,) 1835, which contains a very copious account, but is not complete as regards the numerous recent observations. The best and most comprehensive view of the whole subject of generation, grounded on personal observation, which we possess, is that by Dr. Allen Thomson, in his article, Generation, in *Todd's Cyclopædia of Anatomy and Physiology*, vol. ii. The writings of Wolff, Blumenbach, and others will be particularly quoted by and by.

body of an animal just killed, or a perfectly recent human subject, that the semen may be studied before it has undergone any change. A small quantity of albumen, or of the serum of the blood, has no effect in altering the semen, and affords the best means of diluting and spreading sufficiently the globule of spermatic fluid destined for examination. Properly reduced and extended, the fluid is then to be covered in the usual way with a thin plate of glass (or mica[2]). Under a magnifying power of three or four hundred diameters, there is immediately brought into view a multitude of minute bodies, closely crowded together even in the attenuated fluid, and among which, when the semen is that of an animal but lately dead, a more or less active motion prevails. These moving bodies, ever since their discovery, have been spoken of under the name of the *seminal animalcules*, or *spermatozoa*[3]. At first sight, if un-

[2] Albumen, or, still better, serum of the blood, is the best thing for diluting organic fluids, or covering the surface of tissues, which we would analyse with the microscope. Pure water generally produces some change; but water with from one-tenth to one-twentieth of sugar or common salt dissolved in it, may in many cases be substituted for the fluids above mentioned. A little practice enables us to determine the proper degree of dilution, &c. Blood-serum is, perhaps, most quickly and conveniently obtained from frogs, which it is now the custom with all who give any attention to physiology, to keep by them alive through the whole year. The heart of one of these animals is opened, and the blood allowed to flow into a test-glass of narrow diameter, where it is beaten or stirred with a glass rod; after a time, the globules begin to separate, and by-and-by fall to the bottom, the serum swimming above them. This fluid will keep for a considerable number of days even in summer; in winter, of course, it remains unchanged much longer. Pieces of glass are conveniently used in many cases for covering objects for the microscope, where they do not suffer from pressure. The seminal animalcules are so small and delicate, that their motions do not appear to be impeded in the slightest degree by the pressure of one plate of glass upon another.

[3] The discovery of the seminal animalcules is cotemporaneous with the invention of the microscope. A student from Leyden, named Ham, appears to have been the first (August, 1677,) who observed them. He shewed them to Leeuwenhoeck, who followed up the discovery as an object of science, and communicated the results of his observations to the Royal Society of London. Leeuwenhoeck's excellent observations and figures are contained in the collection of his works, entitled *Opera Omnia s. Arcana Naturæ*, 4to. Lugd. Batav. 1722; and, in the *Arcana Naturæ detecta*, ibid. 1722, (published as a second volume to the foregoing work). Later and very useful observations are contained in Von Gleichen's *Treatise on Seminal and infusory Animalcules*, (*Abhandlung über die Samen- und Infusionsthierchen oder über die Erzeugung, &c.* Nürnberg. 1778), 4to. The publication of the numerous observations and figures of Messrs. Prevost and Dumas (in various volumes of the *Annales des Sciences Naturelles*), may be said to mark a new epoch in this subject. Czermak's Contributions to

diluted semen have been used, the entire fluid appears to consist of these animalcules. With more careful examination, however, other minute, round, granulated bodies may almost always be detected. At one time these are seen singly, and few in number; in others they are more abundant; in every case, however, they are much less numerous than the spermatozoa. These bodies may be distinguished by the name of *seminal granules, granula seminis.* Both elements of the semen are suspended in a small quantity of perfectly homogeneous fluid, transparent and as clear as water. This *liquor seminis* is most distinctly seen around the edges of a drop of undiluted spermatic fluid brought into the field of the miscroscope. Frequently, or indeed commonly, the liquor seminis is present in such small quantities, that it is discovered with the utmost difficulty. It may, however, be frequently rendered more obvious by the use of some reagent, such as acetic acid or alcohol, by which the fluid, albuminous apparently in its nature, is coagulated, and then appears as an exceedingly delicate granular matter, intermixed with the spermatozoa and seminal granules. Pure semen, therefore, in its most perfect state, consists principally of *seminal animalcules* and *seminal granules,* both of which are enveloped in a small quantity of fluid, which I name *liquor seminis.*

§ 4. The LIQUOR SEMINIS, from its transparency and homogeneousness, cannot be made the subject of any more particular microscopical inquiry. We possess no means of isolating it, and investigating its nature apart from the other elements of the spermatic fluid, as we do in regard to so many of the other animal

the history of Spermatozoa (*Beiträge zu der Lehre der Spermatozoen,* Wien, 1833), is, as its title implies, especially devoted to the Spermatozoa; the more delicate details in regard to outline are overlooked in the figures attached to this treatise, apparently from the use of too high a power, and an instrument deficient in definition. I myself gave a short critical notice of antecedent labours, and added many new representations of the seminal animalcules, particularly of the vertebrata, in my *Fragments on the Physiology of Generation,* and *Contributions to the History of Development,* which are contained in the second volume of the Transactions of the Royal Academy of Sciences of Bavaria, for the year 1837. (*Abhandlung der Mathem. Phys. Klasse der Königl. Bair. Akad. der Wissenschaft.*) Siebold, of Dantzig, has given excellent and very accurate observations on the spermatozoa of the invertebrata especially, in Müller's *Archiv für Physiologie,* (1836, S. 13, und 232; 1837, S. 381). I would also refer to the copious critical extracts from Siebold's and my observations in Valentin's *Repertorium,* Bd. 2, S. 133 (1837). The opinions and knowledge in regard to the seminal animalcules of the older writers will be found displayed in a very complete manner in Ehrenberg's recent great work on the *Infusoria* (*über die Infusionsthierchen,* S 465.)

fluids,—the blood for instance. In animals, with blood-globules of considerable size, such as frogs, it is easy to separate the liquor sanguinis from the solid elements by simple filtration; the serum passes through, the globules remain upon the filter. But the filter stands us in no stead in regard to the spermatozoa; these are too minute to be stopped by the meshes of any filter we can use; they pass through with the liquor seminis; and then, the thick and tenacious semen adheres so intimately to the surface of a filter, that frequently nothing whatever will pass. If a quantity of spermatic fluid be left standing for several hours or days in a test-glass, still the liquor seminis does not separate, or at most it appears as a thin line around the edge of the fluid[4].

The SEMINAL GRANULES resemble the granules of the lymph. They are colourless bodies, that yet present pretty dark outlines, round, or perhaps somewhat flattened in shape, having, as it seems, a finely granular surface, and measuring in general from the $\frac{1}{300}$th to the $\frac{1}{500}$th of a line in diameter, (fig. 1. *a e*, and particularly fig. VI. A, *c*, and fig. VII. *b*). Whether they have a nucleus or not, has not yet been certainly ascertained[5]. Besides

[4] It is most easy to obtain conviction of the existence of the liquor seminis in the manner already mentioned (§ 3), namely, by the addition of a drop of acetic acid or of alcohol to the undiluted spermatic fluid; besides the alteration produced in the spermatozoa by this addition, quantities of fine granular bodies make their appearance. Occasionally the spermatozoa are in such numbers, and the liquor in question in such small quantity, that I have failed to make it manifest in the manner indicated; repeated failures ought not, therefore, to lead to any erroneous conclusion in regard to this matter. The greater number of my experiments were made upon frogs and rabbits, and it was in them that I could most completely satisfy myself of the existence of the liquor seminis. Sometimes, besides the minutely granular bodies, irregular coagula, similar in all respects to those that are produced in albuminous fluids on the addition of re-agents, make their appearance; this is usually more particularly the case about the edges of the drop, where fewer spermatozoa are congregated. The experiment is best made with alcohol; with acetic acid, the cloudiness and minutely granular precipitate are occasioned less certainly or less perfectly; if a mixture of alcohol and acetic acid be used, small coagula are immediately produced.

[5] The seminal granules, *granula seminis*, appear to be regularly constituted, and genuine elements of the spermatic fluid, and by no means altered epithelial cells or nuclei; these last are easily distinguished, mingled with the semen at the same time, and are always to be met with, in consequence of the process of desquamation that is continually going on from the epithelium. They are always paler in colour, more flattened, and have never such dark margins as the proper seminal granules. It must be allowed, nevertheless, that it has hitherto been impossible to say, with certainty, whether these granules are plastic seminal elements,—products of the proper secreting function of the testis, or mere products of the epithelium cells. I have found them in the seminal fluid of man

these corpuscles, others of a different nature are occasionally, but not invariably met with in the semen of the higher vertebrata. These are minute shining globules, having dark edges, refracting the light powerfully, and bearing the strongest resemblance to small fat or oil-globules[6], (fig. VI. B, *a* and *b*, from the testis, p. 26). Occasionally, too, we find molecules of still smaller dimensions, which exhibit the Brownian molecular motion; it is still doubtful whether these are proper and especial corpuscles, or—and this is more probable—detached portions of the other co-existent larger bodies.

As accidental, yet very general and abundant elements of the spermatic fluid must be reckoned the detached epithelium cells, which we must be careful not to confound with the proper seminal granules. Sometimes considerable shreds of epithelium, with the cells tessellated, are observed.

§ 5. The SEMINAL ANIMALCULES OR SPERMATOZOA, by reason of their singular variety of forms, their vital peculiarities and mode of development, are, of all the elements of the spermatic fluid, those which naturally attract the attention of the observer first

and all animals, sometimes very scantily mingled, at other times in great quantities—a fact easily verified, by examining the semen of birds of the same species, of the chaffinch, *fringilla cœlebs*, for example, at different times. It has very certainly appeared to me, however, that in regard to quantity, the granula seminis stand in direct proportion to the energy of the seminal secretion; they are thus infinitely more abundant in birds at the period of the greatest turgescence of the testis, and repletion of the vas deferens, than at any other season. The dimensions of these granules vary considerably in the same animal. The measurements given above are the mean; but granules also occur commonly enough of the $\frac{1}{200}$th, the $\frac{1}{150}$th, more rarely of the $\frac{1}{100}$th of a line in diameter, and down to $\frac{1}{500}$th and $\frac{1}{600}$th of a line.

[6] The bodies mentioned as bearing so strong a resemblance to oil or fat-globules, I have occasionally met with in the fully formed spermatic fluid of the vas deferens of animals of every class. They occur more rarely in man, and in him much more sparingly in the semen of the vas deferens than in that of the tubuli of the testis itself. The globules vary in their dimensions, but, in general, they are smaller, less definite in their outline, never granulated or punctuated on their surface (so that they are not aggregates of any finer molecules), and, with a little practice in the use of the microscope, readily to be distinguished from the granula seminis. Globules of the kind now under consideration, and of the $\frac{1}{800}$th of a line in diameter, I have repeatedly, but not invariably detected in the seminal fluid of the hedgehog, for example, of the bat and other animals. Now and then these very minute globules were observed to flit rapidly across the field, in virtue of a faculty of motion apparently inherent in themselves, of a power certainly not referable to simple molecular motion. Are they monads? ova of the spermatozoa?

and most powerfully. They exist in the semen of all animals capable of procreation[7]; in plants, also, some insist upon having discovered elements of the same description[8]. The animalcules

[7] Men and animals are capable of procreating only at or within certain ages. In these latitudes the period of PUBERTY, when the capacity of engendering is first developed, arrives generally between the fifteenth and eighteenth year in the male, and is proclaimed by involuntary nocturnal discharges of the spermatic fluid; in the female the age of puberty is usually attained between the thirteenth and fifteenth years; now and then it is reached as early as the twelfth year, and sometimes even sooner. The period of sexual maturity in the female is proclaimed by the appearance of the catamenia, or menses (*menstruation*); every four weeks, according to the rule, a discharge of blood takes place from the uterus; this discharge lasts for several,—three, four, or five days, and is accompanied by the detachment or exfoliation of the delicate epithelium of the mucous surface of the uterus, which is again and speedily reproduced. The excreted blood is little disposed to coagulate, and generally of a dark colour. Among animals a similar phenomenon has been observed only in monkeys and bats. In man and the domestic animals, birds as well as mammalia, the germ-preparing sexual organs are usually at all times active, and reproduction may take place at every season; among wild animals, on the contrary, the reproductive faculty is limited to a certain short period of the year; the time during which the sexual inclination prevails among animals is called the *heat*, the *rut*, &c. It mostly occurs early in the spring, sometimes in the autumn. It is during this period only that the testes and sexual organs are turgid, and that seminal animalcules are abundantly and regularly produced. In the human female the capacity of reproducing is generally lost between the forty-fifth and fiftieth years; in the male the reproductive energy declines only as he advances in years; healthy men seem capable of engendering to the very end of their lives, and examples are not wanting of men in their seventieth, eightieth, and even their hundredth year, and more, becoming fathers. Thomas Parr, in his hundred and forty-second year, showed himself still capable of fruitful sexual intercourse. I have constantly found seminal animalcules in the fluid of the testis of very aged men; it is only among weakly and decrepid individuals that the procreative faculty is really lost.

[8] With regard to the so-styled animalcules of the pollen-fluid of plants, opinions even among the latest and best observers are very much divided. The pollen and the pollen-capsule contain a somewhat tenacious fluid, in which minute bodies are suspended; this matter of the pollen-globule has been regarded as the vegetable seminal fluid—*Fovilla*; Adolphe Brongniart compared its suspended molecules to the seminal animalcules, and even observed the bendings that take place in them in the Hibiscuses and Œnotheras (vide his *Rech. sur la Génération*, &c. in *Ann. des Sc. Nat.* XII. p. 34. 1827). Similar observations have been made by Mr. Brown, On the particles contained in the pollen of plants, &c. Lond. 1827, and in *Vermischte Schriften*, Bd. IV. S. 146). Others, again, Hugo Mohl, &c. have denied all change of form in these molecules, and regard them as mere starch-granules (vide Mohl's *Beiträge zur Anat. u. Physiol. der Gewächse*, I. S. 32). Mohl found the smallest granule of the Fovilla which he could measure to be the $\frac{1}{1000}$th, and the largest the $\frac{1}{100}$th of a Paris line in diameter. Many observers reduce all appearances of motion in these granules to mere molecular movement. Meyen, on the other

must be examined, as obtained from the epididymis, or vas deferens, if we would observe them possessed of their most perfect form, size, and vital endowments. The first circumstance that strikes the observer in regard to these animalcules, is their diversity of form in the different classes, genera, and species of animals. In Man (fig. 1, *a*—*d*), they are extremely small, scarcely sur-

hand, maintains that the seminal animalcules are particularly obvious in the Œnotheras; and, again, Schleiden (in Wiegmann's *Archiv*, 1838, S. 56) proclaims all the spermatozoa of plants to be mere starch-grains. Fritsche, in his very excellent observations on Pollen (*Beob. über den Pollen*, Petersburg, 1837), expresses the same opinion. The elements of plants that bear the closest resemblance to the spermatozoa of animals, are those granules with tails which are found in the capsules of the mosses, and which, as obtained from the genus *Sphagnum*, were already subjects of observation among the older inquirers. Unger and Werneck have given a particular account, and published figures of these bodies, and regard them as true spermatozoa (*Regensb. Botan. Zeitung*, 1834, S. 145). Meyen has very recently described minutely the caudate spermatozoa of the anthers of *Marchantia polymorpha* (Wiegem. *Archiv*, 1838, S. 212). Valentin holds the bodies in the Fovilla of vegetables to be merely Brownian molecules; he has not observed the animalcules of Sphagnum and Marchantia; the grand criterion of true spermatozoa, viz. internal organization and development in cysts, has never been asserted in regard to the so-styled spermatozoa of plants (Valentin's *Repertorium*, 1838, S. 63). I have not myself, I regret to say, had any opportunity of making observations on Sphagnum, having for several years sought in vain for anthers in specimens of this genus procured from the most opposite habitats. In other mosses, however, Orthotrichum, Fumaria, &c. I have never discovered any caudate corpuscles, and the contents of the anthers appeared to me to be affected only by the universal molecular motions, which proceeded amidst tincture of iodine as before. In the

Fig. I.

Fig. I.—Spermatozoa (magnified from nine hundred to one thousand diameters) taken from the vas deferens of a man shortly after death; *a*, spermatozoon presenting the flat surface; *b*, ditto, viewed in profile, the margin being presented; *c*, ditto, presenting the circular spot on the surface, which some suppose to be a sucker; *d*, a spermatozoon exhibiting a process from the anterior extremity of its body, not unlike a proboscis; *e*, seminal granules.

passing the $\frac{1}{50}$th, and, at the very most, the $\frac{1}{40}$th of a line in length. The little, oval, somewhat flattened, almond-shaped, and perfectly transparent body, seldom exceeds from the $\frac{1}{600}$th to the $\frac{1}{800}$th of a line in length; the filiform tail at the top is thickish, and so strong, that the double contours are plainly visible; but, towards the end, it becomes so fine, that it cannot be followed even with the highest powers to the point; so that it is possible the delicate extremity proceeds farther than it can be traced, and that the animalcule is actually longer than it can be determined to be by micrometic admeasurement[9]. In the Mammalia, the spermatozoa

anthers of Marchantia polymorpha, however, besides the minute black globules, I observed several green corpuscles, the rapid motions of which seemed to indicate the existence of a tail; this was also made completely manifest by the addition of tincture of iodine, which arrested the motions. These green corpuscles are decidedly smaller than human spermatozoa. I have not observed with equal precision the peculiar larger, elongated, yellowish, transparent corpuscles of the Fovilla of Œnothera biennis and other species; the motions of these, however, I may say, appear to me to be of a voluntary or spontaneous kind. The length of these corpuscles varied between the $\frac{1}{600}$th and the $\frac{1}{800}$th of a line; in tincture of iodine they became quiescent and opaque, and resembled aniseeds in shape; the motions of the smaller molecules continued after the addition of the iodine. (See farther on this subject the observations under annotation 69, to § 22.) On the older researches of Brongniart and others, see the Summary in Von Roeper's translation of De Candolle's *Physiologie Vegetale,—die Pflanzen-physiologie,* &c. Bd. II. S. 103. Meyen proposes to treat the entire subject in the third volume of his *Pflanzen-physiologie.*

[9] Dujardin (*Ann. des Sciences Nat.* VIII. p. 293, and pl. 9, 1837) describes and figures certain irregular knots and lobular enlargements at the root of the tail of human spermatozoa. These appearances I have myself observed, but they only occur as effects of certain alterations undergone by the animalcules, in consequence, for example, of their long stay in urine, especially when this fluid contained at the same time a quantity of puriform sediment. I have always found the size of the bodies of the spermatozoa to be very nearly the same in the same individual. But on the other hand I have noted them of such dissimilar magnitudes in different individuals, that I was led to regard this as more than accidental, and as a consequence of changes undergone either from the different periods that had elapsed since the death of the individual, or from the influence of the fluids, the urine for instance, with which they had been in contact. I therefore instituted a series of inquiries on the bodies of suicides, in as fresh a state as possible, and mostly of strong men. In one man of twenty years of age, and in another of fifty (both of whom had put an end to their lives by hanging), I found the bodies of the seminal animalcules exceedingly small and roundish, the $\frac{1}{800}$th of a line and under in length; in a third individual, in his fortieth year, who had also hanged himself, I, on the contrary, observed the animalcules all of very large size, the bodies being about the $\frac{1}{500}$th of a line in length. The whole of them were very nearly of the same size, and greatly resembled one another. Farther observations on this point would be interesting. Occasionally the seminal animal-

present very similar forms (fig. III. 1—9); but they are generally larger than in man, and this more especially among the smallest animals: in the genus Mus they are perhaps larger than in any other family; in the rat, for example (fig. III. 7.), they are of the $\frac{1}{12}$th of a line, and perhaps more, in length; the body measures from the $\frac{1}{150}$th to the $\frac{1}{200}$th of a line; the tail is here thick and strong, and easily traced to its extremity. The forms of the body, or anterior thicker end of the spermatozoa, are manifold: in apes (fig. III. 1) these animalcules resemble those of the human subject; they are only somewhat larger: in the mole (fig. III. 3) they are longer; they are more pyriform, but also greatly flattened and very various, both in figure and size, in the dog (fig. III. 4), in the rabbit (fig. III. 5), in the roebuck (fig. III. 9), and still more in the genus Mus:—in the rat (fig. III. 7) the body posteriorly is sickle-shaped, arched, and extremely compressed, but long; the tail springs more from the upper and back part of the body; a great general resemblance to this last form is apparent in the spermatozoon of the common mouse (fig. III. 6), only the body is shorter; the point above, merely indicated and scarcely bent, resembles, when viewed from the side, a round-edged scalpel (*a*); the body is deepened posteriorly where the root of the tail is set on (*b*); these particulars are still more strongly seen in the field-mouse (fig. III. 8, *b*), the body

cules exhibit a yellowish, even an amber, tint. Perhaps this is a mere effect of refraction. As a remarkable departure from the normal form, I have upon two occasions observed the caudal end of the body double, bifid, or forked; I do not imagine that I was deceived in these cases. Once, too, the body appeared to be double, as in a bicephalous monster; it was attached to the bifid or forked root of the tail, and grew together or was connected along the middle line; this observation, however, was not so complete as to leave me free from doubts as to its absolute accuracy.

Fig. II.

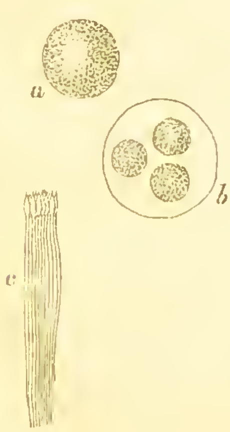

Fig II.—Semen from the testicle of a man magnified from nine hundred to one thousand times:—*a*, a large roundish corpuscule; *b*, globule of evolution, a cyst which encloses three roundish granular bodies; *c*, a bundle of seminal animalcules, as they are grouped together in the testicle.

is therefore still more obtuse, superiorly and posteriorly, when seen from the side [10].

[10] The study of the varieties of form presented by the seminal animalcules ought not to be held as any trifling matter, or as tending to accumulate superfluous details; most important physiological conclusions may be based on the information thus acquired. Whether or not the varieties in point of size, and the more delicate shades of difference in regard to form, which are exhibited in the figures, are all constant, is a point still to be determined. In different individuals of the same species, the mole for example, we frequently observe varieties in the relative

Fig. III.

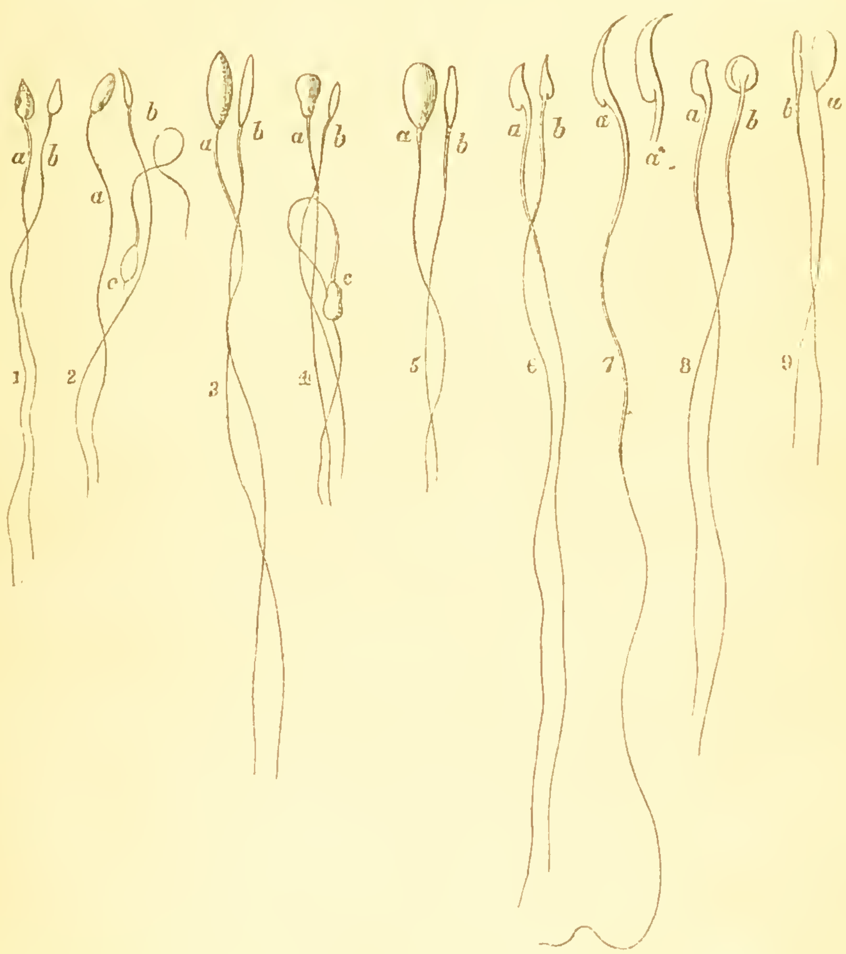

Fig. III.—Spermatozoa from the vasa deferentia of various animals, magnified from nine hundred to one thousand diameters :—*a*, viewed on the flat side ; *b*, on the edge. 1, Spermatozoon of *Cercopithecus ruber ;* 2, of *Rhinolophus ferrum equinum*, the greater horse-shoe Bat (at *b*, and more distinctly at *c*, the process from the body is seen); 3, of the Mole (*Talpa Europæa*) ; 4, of the Pomeranian Dog ; 5, of the Rabbit (*Lepus cuniculus*) ; 6, of the Mouse (*Mus musculus*), *b*, viewed on the posterior surface, showing the root of the tail extending a little higher up ; 7, of the Rat (*Mus rattus*) ; 8, of the Field Mouse (*Hypudæus arvalis*) ; 9, of the Roebuck (*Cervus capreolus*).

Among Birds two principal varieties are observed in the form of the spermatozoa: they have either a long slender body, perfectly cylindrical as it seems, with a tail extremely thin, filiform, and arising at once, not tapering off from the body, and once or twice as long again as this part; this appears to be the type in the Rapaces, Scansores, Gallinæ, Grallæ, and Palmipedes; or the cylindrical body is pointed anteriorly, and then makes several, generally from three to four, spiral turns, so that it resembles a corkscrew, and then tapers off gradually into a long straight tail, that grows smaller as it approaches its end. This is the type in the Passeres (fig. IV. *a, c, d, f, g*). The number of spiral turns, and the angle at which they proceed, are different in the different families and genera. The tail is of very dissimilar length and thickness. If the spiral be much drawn out and more sinuous in its appearance, the turns pass into each other under blunter angles, as in the Thrushes for example (fig. IV. *f*.); in the Shrikes (Laniadæ), again, the spiral is greatly contracted, and the turns appear almost acutely angular (*g*); the tail is here short and delicate, so that the whole animalcule measures but from the fiftieth to the sixtieth of a line in length; whilst in the Finches (Fringillidæ) they are much larger and stronger; in the Chaffinch, for instance (Fringilla cœlebs, fig. IV. *a*), they are the sixth of a line in length, the tail is very strong and rigid, and here, as among the Passeres generally, is never observed to move in the motions of the animalcule.

In the scaly families of the Amphibia, the lizards and serpents, the spermatozoa have for the most part an elongated body, and a delicate, filiform tail, like those of birds in general (*e.g.* the common

dimensions of the body of the spermatozoa; but this depends in part, at least, on the degree of dilution of the semen, on its freshness, on the degree of liveliness or power of motion, &c. &c. exhibited by these animalcules. The descriptions here given, and the forms presented, are all from spermatozoa in the most recent state possible. In beginning the study of the spermatozoa without assistance, I would particularly recommend the rodent tribes as the proper subjects, by reason of the magnitude and the decisive forms peculiar to their seminal animalcules. Let any one, for example, compare the seminal fluid of the mouse and rat, and he will immediately find that the spermatozoa of these two so closely allied animals present typical similarities not to be mistaken in the important matters of size, form of body, &c. &c. at the same time that they still exhibit specific differences adequate to distinguish them in every case from one another, and when they are contrasted. Other rodent animals, the squirrel, to cite a single case, have very peculiar and large spermatozoa, the margins of the body being turned up in some sort like the brim of a hat, &c. &c. Large animals, the horse, the ox, &c. have smaller and less specifically and obviously diversified spermatozoa, so that it is not so well to begin with these animals in analyzing the seminal fluid.

fowl, fig. IV. *i*). Those of the Frogs (Ranidæ) are of the same description; but among the other Batrachia, the greatest diversity

Fig. IV.

Fig. IV. — Spermatozoa from the vasa deferentia of several birds, magnified from nine hundred to one thousand diameters:—*a*, of *Fringilla cœlebs*; *b*, a perfectly formed cyst from the testicle of the same bird, containing a bundle of the spermatic animalcules; *c*, of *Fringilla canaria*; *d*, of *Fringilla carduelis*; *e*, imperfect spermatozoa from the testicle of a hybrid beween a male *Fringilla carduelis*, and a female *Fringilla canaria*; *f*, of *Turdus merula*; *g*, of *Lanius ruficus*; *h*, of *Picus viridis*; *i*, of *Gallus domesticus*.

of form prevails; those of the land and water Salamanders (Tritonidæ) may be cited as the most remarkable in this respect[11]. In this family the spermatozoa have a long body that tapers to a point anteriorly, and ends in a small tuber or button, from which issues a tail that becomes more slender as it proceeds, and of which the extremity is turned back, and is wound spirally several times about the whole body.

The spermatozoa of the Rays and Sharks among Cartilaginous Fishes, appear to be long and filiform; among bony fishes, again, their bodies are globular, sometimes provided with a projecting part or process, to which is attached a tail of considerable length, but so excessively delicate, that it is always discovered with difficulty.

The spermatozoa of the Invertebrata generally are elongated in their shape, hair-like, and extremely delicate; this is the case with the majority of insects. They have the same general characters, but are thicker and singularly long in the Mollusca; some of them are as much as half a line in length, and occasionally presenting a thicker and better developed extremity, which in certain cases, in the Mussel for instance, even assumes an oval form, they bear a very considerable resemblance to the spermatozoa of the Mammalia[12].

[11] The spermatozoa of singing birds form on these accounts very excellent subjects for initiatory observation. Specimens of singing birds of different genera and species are easily procured, too, for contrast, and I have therefore kept them particularly in view, both in the present and the next paragraph (§ 6). The vas deferens, divided in the vicinity of the cloaca, supplies us with the seminal fluid in abundance. How far the constant diversities of form in the spiral, and of size obtain, and how these bear relation to particular families of singing birds, and again, to particular species of them, requires to be made the subject of farther inquiry; the varieties indicated in reference to the shrike and finch, perhaps also to the thrush kinds, I am inclined to regard as family characters. It is remarkable, that all the birds without the singing muscular apparatus, which I have examined, which were formerly arranged in one order along with the true Passeres, and first detached from these by Nitszch—to wit, the genera Coracias, Caprimulgus, Alcedo, have not, any more than the Cuculidæ, Picidæ, and others of the Seansores order, the corkscrew-form of spermatozoa, whilst the Corvidæ, or crow-kinds, present precisely the same peculiarity in the constitution of their seminal animalcules as the true singing birds. Among the naked Amphibia, besides the land and water salamanders, the spermatozoa of which are very similar, yet different, the genera Bombinator and Pelobates have very peculiar seminal animalcules.

[12] The spermatozoa of the Invertebrata, however interesting they may be under other points of view, can only be briefly alluded to here, the investigation of the varieties of form, &c. described as occurring among mammalia and birds being

§ 6. A question of the greatest moment presents itself here, which, were it answered definitively, would leave no farther doubt in regard to the animal nature of the spermatozoa. It is this: Do the spermatozoa possess an internal organization, like the Entozoa and Infusoria? for the care and patience of experienced observers, aided by the excellence of our modern instruments, have demonstrated, even in the smallest, and apparently simplest forms of the Infusoria, organs performing especial offices, in particular a complicated digestive apparatus. Opinions are greatly divided in regard to the way in which the question proposed must be answered. The spermatozoa were formerly referred to the Cercariæ, being named *Cercariæ Seminis*, and some most careful observers of the present day defend the propriety of this disposition [13]. Some have thought, that in the middle of the flat bodies of the spermatozoa, even of the human subject, they could discover a sugient orifice, similar to that which exists in the Cercariæ and Distomata [14]; others will have it, that they can make out ventricular sacs, as in the polygastric Infusoria [15]; and in direct opposition to all of these, there are others, who, with the highest magnifying powers, and the most anxious observation, have failed to perceive, with any thing like certainty, traces of internal organs in the transparent

sufficient to serve as grounds for the physiological conclusions immediately to be drawn, so that any farther detail seems unnecessary, and only likely to lead to confusion. Siebold has paid particular attention to the spermatozoa of insects, and described them minutely in the place already referred to. For an account of numerous other differences observable in the spermatozoa of various animals, I beg to refer to my *Aufsätze und Abhandlungen, im Denkschriften der Münchner Akademie,* and in Wiegmann's *Archiv,* Jahrg. 1836, 1837, 1838. I shall give a full account of all the known spermatozoa in the article SEMEN, in Todd's *Cyclopædia of Anatomy and Physiology.*

[13] That the manifold forms of spermatozoa, which I have shown to occur in the seminal fluid of a great number of animals, must be viewed in the light of so many different species, in case their animal nature is ever demonstrated, cannot be doubted; so that the expression *Cercaria Seminis* is only a collective title.—Vide Wiegmann's *Handbuch der Zoologie,* S. 584. Ehrenberg has also lately referred the seminal animalcules to the haustellate Entozoa.—Vide his recent great work, *Die Infusionsthierchen, &c.* fol. Leipz. 1838.

[14] Henle and Schwann recognize a middle sugient depression in human spermatozoa; it is undoubtedly the spot or macula described in the text to which they refer. Wiegmann, however, informs us, (*Archiv,* Bd. II. S. 134, 1837), that Henle has now abandoned this idea.

[15] Valentin speaks in various places of the polygastric structure of the spermatozoa, and says lately (*Repertorium,* 1837, S. 134), that " the clear spermatozoa of the bear, which in external form approach those of the rabbit, present distinct

bodies of the spermatozoa [16]. The excessively delicate or criniform spermatozoa of the invertebrate classes, resemble crystalline threads, without any kind of visible structure; neither in, nor on these, is there a trace of cellular, granular, or fibrous tissue to be detected. Those spermatozoa, however, which have a thicker or broader body—a part different from that which is filiform, do exhibit in this part the appearance of a fine granular tissue, which, under the highest magnifying powers that have yet been attained, cannot be decompounded into cells or other elements. Here, too, in the middle of the flat surface of the animalcule, a minute speck or spot, which often presents itself in the guise of a ring or a semicircle, is occasionally observed. This is the spot which has been pointed out by some as the suctory or absorbing orifice. This spot is represented in the seminal animalcule of the human subject in fig. I. *c*, *c*, (p. 8), and in that of the dog in fig. III. 4, *a*. (p. 11). Now and then, also, but by no means constantly, a small prominence or trunk-like process is observed on the anterior part of the body of the human spermatozoon (fig. I. *d*, p. 8); this, or a corresponding part, is more obviously, and much more regularly present in the seminal animalcule of the bat, in which it

traces of internal organization, to wit, an interior and posterior haustellate mouth, and internal cavities or convolutions of an intestine."

[16] The most varied, repeated, and long-continued examination has not enabled me at any time to discover true internal organs in the spermatozoa; and one of the most laborious and accurate observers of these animalcules, as well as most learned investigators of the more delicate structure of the entozoa, Dr. S. Siebold, coincides entirely in my views. (Siebold, in Wiegmann's *Archiv*, f. 1838, I. S. 303.) All that I have ever been able to make out is comprised in the statements in the text. Vide farther my remarks on the suspected organs of the spermatozoa, in my *Fragmente zur Physiologie der Zeugung*, S. 406. The darker-coloured macula bearing some resemblance to a haustellate orifice, I have now and then perceived in other spermatozoa, in those of the rabbit for example. The apparent spine implanted anteriorly on the body of the spermatozoon of *Rhinolophus* is by no means constant, and is never so distinctly seen, but that doubts of its import mingle with our observations of its existence; if it be an actual styliform process, the structure recalls that peculiarity which was first described by me in the cercaria armata. (Vide *Isis*, Jahrg. 1834, S. 131; and farther, Siebold, in Burdach's *Physiologie*, Bd. II. S. 192. 2te. Aufl.) I would here observe generally, that the nomenclature adopted in regard to the spermatozoa, such as body, head, tail, &c. is merely provisional, and will be either confirmed in its propriety, or rejected when farther progress is made in our knowledge of the minute anatomy of these corpuscules,—when the true import of the several parts that enter into their constitution shall have been discovered. It is not impossible but that, as in the case of the trichocephalus, the thinner filiform extremity which we at present entitle tail, may be found to be the head, &c. &c.

occurs as a pointed spine (fig. III. 2. *b c*, p. 11). Finally, the conjectural spermatozoa of the actinæ, exhibit evidence of a compound structure, but which is also capable of being interpreted in another way [17]. On reviewing all that has just been said, it is plain that at the present time no decisive answer can be given to the question regarding the animal organization of the spermatozoa. All that is yet known, or has been presumed upon the matter, reduces itself to this: that certain indistinct traces of organization have been discovered, but that these are by no means sufficient to be made the grounds of any positive conclusions.

§ 7. In what light are we to view the motions of the spermatozoa, and how are they effected? Have they any character of volition, and can any inference be drawn from their undoubted occurrence favourable to the idea of the independent animal nature of these bodies? These questions deserve the most careful consideration. To observe and compare the phenomena that accompany the motions of the spermatozoa, they must be studied under a variety of circumstances. When a drop of thick semen from the vas deferens, properly spread upon a piece of glass, is brought under the microscope, it frequently happens, even when the semen employed possesses considerable vitality, that nothing more than a general sluggish intestine movement is visible amid the crowded masses or heaps of spermatozoa. The appearance is as if they strove to disentangle themselves from one another in the tenacious fluid. If a little serum of the blood be now added to the drop of semen, the motions speedily become more lively; sometimes this happens suddenly, sometimes more gradually. Individual animalcules shake themselves once or twice, turn on their axis, strike with the tail, toss the head extremity once or oftener, and begin to make their way in all directions across the field; the motion extends to continually increasing numbers of other animalcules in succession; here and there every one of a cluster seems to arouse itself simultaneously; or otherwise, only a few that lie near each other in the mass put

[17] On the spermatozoa of the actiniæ, see my memoir in Wiegmann's *Archiv*, f. 1835, Bd. II. S. 215. I formerly believed that I had found spermatozoa having very peculiar characters in those organs of the actiniæ which are generally regarded as testicles: elongated, yet thick bodies, which suddenly throw out a filiform very long tail, which appeared to have been inclosed spirally within the body. Analogy and farther study lead me to doubt of the accuracy of the opinions I then formed. May not the oval bodies in question be capsules or cysts, in which the true spermatozoa, extremely elongated and filiform, are developed, and out of which they make their exit in the form of tails? This view I am at present inclined to think maintainable.

themselves in motion, whilst the rest seem to lie passive, and sometimes will continue so through the whole course of the observation, though frequently, too, they begin at length to stir in a greater or less degree, like those that first awoke. The motion in the globule of semen, thus attenuated with serum, appears throughout to have the character of regularity, certainly not of anything violent or forced; it is modified according to the form and dimensions of the spermatozoa; is the motion rapid, then the spermatozoa, as in the greater number of mammalia, bony fishes, acephala, &c., exhibit a pendulum-like rhythmical movement, the criniform tail vibrates vigorously like a whip, and the little body or head obeys the impulse thus communicated to it. When the motion is slower, a kind of serpentine or sinuous vibration of the tail in all directions is apparent. The rigid, straight, outstretched spermatozoa of the passeres, with spiral bodies, very commonly spin themselves round on their axis, and so advance in the manner of a piercer or screw; then they rest, and again they strike to the side, and advance in different directions, with a wavering and unsteady motion. The spermatozoa, with elongated cylindrical bodies and slender tails, like those of the other families of birds, of frogs, &c., scull themselves forward with their tails, either striking them slowly, and with wide sinuosities, or more quickly and shortly, as when a whip is shaken; they thus advance in circles with a quivering motion, holding the body extended in a straight line, though they also now and then bend this in various directions from side to side. The spermatozoa of the salamanders and tritons commonly lie coiled up in a circle like a watch-spring; then there arises a jerking tremulous movement, in which they seem to spin round in a circle upon one point as a pivot; along with this there is a lively, glistering, and wavy motion, that recalls those movements of the mucous surfaces which are produced by cilia, but which, on attentive examination, are here seen to depend on a rapid rotatory or spinning movement of the very delicate tail wound spirally about the body. Some of these spermatozoa too are occasionally seen to stretch themselves out, and to cross the field of the microscope with slow serpentine motions [18]. The various

[18] At an earlier period of my investigations I believed that the glistering unsteady motions of the spermatozoa of the salamanders were the effect of a ciliary apparatus, and even dilated on this as a means of locomotion in my *Fragmente*, already quoted, (p. 394, tab. II. fig. XVII. *u.* XVIII.) Siebold was the first who correctly referred to the spiral disposition of the tail around the body as the cause of the phenomenon, (V. Froriep's *Neue Notizen*, Bd. II. S. 281, No. 40.) I have very lately fully satisfied myself of the accuracy of this view.

motions of the spermatozoa now collectively described may be taken as the normal movements of these animalcules deduced from numerous particular observations; they strikingly impress the mind of the observer from first to last with the idea of spontaneity or volition; we cannot, certainly, refer them either to the motions entitled molecular, or to those that are ciliary in their origin; neither are they the effects of actions produced by hygroscopic or any other simply physical influence[19]. They agree in every thing with the motions immediately to be described, which take place in the spermatozoa of the seminal fluid that has been mixed with other secretions in the act of ejaculation.

§ 8. The spermatozoa of the semen which has undergone natural dilution by admixture with mucus, the fluid of the prostate, &c. (and which may be procured for examination from animals that have just copulated,) exhibit motions similar to those described in the preceding section, with this difference, that here they are quicker and more powerful; the animalcules of a globule of this semen swim very rapidly, with a vibratory and tremulous motion across the field. Hours, and even days after the sexual act, they may be discovered still possessed of the same activity amidst the

[19] The various very remarkable movements here described must be particularly studied by the young physiologist, that he may be enabled to distinguish them, and be placed beyond the risk of being deceived. The purely mechanical motions that occur in the corpuscules of different kinds suspended in fluids, when placed upon the stage of the microscope, in consequence of the instrument not standing perfectly level, of the unequal pressure of the plate of glass or mica which covers the globule of fluid examined, or of the presence of air-bubbles, &c. &c. will soon be distinguished by beginners. The peculiar molecular motion first accurately described by Mr. Robert Brown, (*A brief Account of Microscopical Observations on the Particles in the Pollen of Plants, and on the general Existence of active Molecules in organic and inorganic Bodies*, 8vo, Lond. 1827,) is observed in a vast variety of substances when finely pulverized. The black pigment of the choroid coat of the eye affords perhaps the best of all subjects for its study. A little of this pigment from the eye of an ox exhibits the dancing motions, the attractions and repulsions of the finest particles that characterize the phenomenon in great perfection. The true cause of this movement appears to be purely physical, but it has not yet been quite satisfactorily explained. On the incessant currents that occur in fluids, see the observations of Mohl, in his *Physiologie der Gewächse*, Heft I. S. 31 (1834). The ciliary motions, of which particular mention will be made by-and-by, are the effect of small vibrating cilia or hairs, free towards their points, and attached to tegumentary surfaces by their bases. The phenomena of ciliary motion are conveniently studied on a piece of the gill or mantle of the common fresh water mussel.—(Vide Dr. Sharpey's excellent article Cilia, in Todd's *Cyclopædia of Anatomy and Physiology*, in which the whole of the facts connected with this curious subject are exposed.)

mucus of the vagina and uterus. Common mucus and saliva have no hurtful or repressing influence on the motions of spermatozoa[20]. Even in urine and in bile they continue active, though for a shorter period; occasionally the motions cease suddenly; the animalcules start, as it were, a few times, and then lie quite still; often, too, they seem affected with strong convulsive-like motions; these last are still more speedily induced by the admixture of pure water. In the majority of instances, when pure water is added to a drop of semen, there suddenly occurs a rapid movement, a sudden commotion in the whole mass of seminal animalcules; they shoot about in all directions, and individuals may be observed bending or twisting themselves violently, so that the tails frequently become entangled, and form knots. Shortly afterwards the whole mass becomes quiescent, although one here and there may still be observed to move, or to be twitched convulsively, and this sometimes very violently. A speedy addition of blood or serum is occasionally followed by the return of regular motions, which, however, are never of any duration. Weak solutions of sugar or of salt in water produce these powerful effects either in a less degree or not at all. The addition of a very small quantity of pure water, too, seems frequently to have no influence in arresting the motions of the spermatozoa; and it is remarkable, that these animalcules manifest very different susceptibilities to the action of water pure, or impregnated with some saline matter in different classes, and even

[20] Donné has performed a series of experiments on the influence of different animal fluids on the spermatozoa. (*Nouvelles Expériences sur les Animalcules Spermatiques*, Paris, 1837, 8vo.) Blood produced no ill effects on them; they will live for one, two, three, and even four hours, moving freely, rapidly, and without any loss of strength. Whether the blood employed was that of a man or of a cold-blooded animal, the effect was the same. The motions fall off in vivacity gradually, and the animalcules die without any violent or convulsive phenomena, and remain in the position in which they were previously. Milk has the same influence as blood; spermatozoa will live for hours in this fluid. Saliva destroys them quickly, and in their agony the tail is apt to form eyes or knots. In urine they perish instantaneously. In pus (from chancre and vaginal gonorrhœa) they appear to live as long as in the spermatic fluid itself. The mucus of the vagina is so weakly acid, that the spermatozoa do not seem to suffer from it, although in general they are less affected by fluids that are slightly alkalescent than by those that are in any way acid. These conclusions of Donné I have found correct on the whole; on particular points, however, my own experiments, instituted for the most part on the spermatozoa of the lower animals, led me to different conclusions: I found, for instance, that they almost always lived in saliva; also in urine, particularly when it was kept warm, and was not too concentrated; after a nocturnal emission, for example, although several hours have elapsed, feeble vital motions may still be perceived in the spermatozoa then con-

in different genera of animals [21]. Diluted acids, alcohol, and similar fluids, arrest the motions of the spermatozoa in the instant, and the creatures lie in all irregular positions, and altered in their forms upon the field. The effect of narcotic substances is particularly interesting; watery solutions of the salts of strychnia always arrest the motions suddenly; in general, too, they very soon cease under the influence of solutions of opium and of cherry-laurel water, but without any change in the form of the animalcules being induced [22].

§ 9. The normal duration of the motions of spermatozoa is different in different animals. It appears to be shortest in birds; among which within so short a time as from fifteen to twenty minutes after the death of the animal, it is frequently no longer to

tained in the urine. I have repeatedly detected them in the urine of persons whom I suspected of masturbation; also in urine that let fall a purulent sediment. [Dr. John Davy (*Edinb. Med. Surg. Journ.* vol. 50.) reports that, on examining the fluid from the urethra after stool in a healthy man, he had always detected spermatozoa in it. I have, under the same circumstances, and even after the mere evacuation of the bladder, several times discovered spermatozoa in the fluid of the urethra, but the subjects of my observation were never strong or healthy men; they mostly laboured under anomalous nervous symptoms, which were in all likelihood connected with an irritable or disordered state of the vesiculæ seminales and prostatic part of the urethra. R. W.]

[21] The addition of water almost invariably increases the motion in the first instance. The animalcules rush tumultuously past one another, and die off singly. The spermatozoa of the invertebrata, of amphibia, and mammalia, almost always form loops or eyes; those of the latter not invariably; those of birds again almost never. The spermatic fluid of fishes mixed with water exhibits a commotion that lasts many seconds, and even minutes; after which entire quiescence follows, or only individual animalcules stir. In the spermatic fluid of the common earthworm, the animalcules on the addition of water commove themselves in masses in a wavy manner, by which a singular and beautiful effect is produced, that might be compared to the waving motion of a corn field.

[22] The effect of even the weakest solution of strychnine is always sudden; when the whole of the animalcules in a diluted drop of semen are seen in full activity, all that the poisonous fluid reaches die immediately; the others in the immediate vicinity of these, which it has not attained, still continue to move vigorously. To secure the gradual contact of this solution, and to observe its effects, a piece of cotton or woollen-thread, or a narrow slip of filtering-paper, may be laid in the drop of seminal fluid under examination, and touched at one end with a glass rod dipped in the narcotic solution; by the capillary attraction of the thread or slip of paper the reagent penetrates the drop of semen slowly, and produces its specific effects gradually. I have found the influence of such a narcotic solution of a like potency upon the spermatozoa in mammalia, birds, and amphibia.

be perceived: this is particularly the case when the external temperature is low and the body cools quickly. Occasionally, nevertheless, motion is conspicuous, at least in regard to individual spermatozoa, some hours after the death of the bird from which they were derived[23].

In mammalia the spermatozoa continue to exhibit motion much longer, in some cases even at the end of twenty-four hours after the death of the animal. In amphibia this is still more remarkably the case; and in fishes, when the temperature is not too high, and putrefaction does not take place, the motions of the spermatozoa continue longer than in any other of the vertebrate classes. The spermatozoa continue alive much longer when the semen remains inclosed in its natural receptacles than when it has been taken out of these: this at least is the case in regard to the warm-blooded vertebrata; in fishes, as I have just said, they live on for several days, even out of the body[24].

In weak solutions of sugar and common salt, too, the spermatozoa of vertebrata continue active for six or eight hours; and those of man, after nocturnal emissions, may be found alive in the

[23] I have always observed the most rapid and lively movements among the spermatozoa of birds, particularly passeres of all kinds, killed by decapitation or strangulation. The whole mass of semen examined was alive and quivering, and the appearance it presented might be compared to a packet of sewing-needles shaken rapidly backwards and forwards and about; individual animalcules at the same time were spinning swiftly on their axes, and so on—facts which Siebold certainly does wrong in denying (Müller's *Archiv*, 1837, S. 436). In a single (and rare) instance, I observed the spermatozoa of a lark in motion eighteen hours after the death of the bird, the abdomen of which had also been opened. They may commonly enough be observed to move, in birds that have been shot, two or three hours after death.

[24] In rabbits, mice, &c. that have been killed the night before, the spermatozoa are commonly found alive next day: if a piece of the turgid vas deferens of one of these animals be put into serum or sugar-water, and a drop of spermatic fluid be added at the same time, the spermatozoa will usually be found to continue their motions in the fluid of the vas deferens for a long time after they have become quiescent in that of the added drop. I have found the spermatozoa of frogs, skinned and prepared for cooking, still in motion. Among fishes I have observed the spermatozoa to be singularly long-lived. I once kept a slender test-glass full of the spermatic fluid, obtained directly from the turgid testes of the common perch, for four days in cool weather, and found the animalcules as lively and disposed to comport themselves precisely in the same manner as those of the generality of animals but just killed; the motions were sluggish in the undiluted semen, but became singularly active on the addition of water; they then ceased of a sudden, &c.; they did not cease at a temperature two degrees below the freezing point of water.

urine hours afterwards[25]. Very low or very high temperatures have a like influence in arresting the motions of the spermatozoa; although those of frogs and fishes still continue active when the surrounding medium reaches, or even sinks below the freezing point. The kind of death which an animal suffers has no influence on the duration of the motions of its spermatozoa[26].

§ 10. *Production of the Spermatozoa.*

The genesis, or production and development of spermatozoa are subjects of much interest, and very remarkable; both take place through the entire series of animals after a very similar type, which presents but slight modifications. For the study of this subject, a bird, and that one of the order of Passeres, should be chosen; the circumstance of the pairing time in these creatures being so determinately attached to a certain season, affords us an opportunity of watching the genesis and evolution of their spermatozoa in the most clear and satisfactory manner. The testes themselves, according to their condition, always prefigure the state of evolution of the spermatozoa. In winter the testes present themselves as a couple of small bodies, the size of a pin's head, or a millet-seed; the seminal vessels are then exceedingly contracted, but still demonstrable as tortuous canals, lined with an epithelium. Whether the very minute granular bodies, from the $\frac{1}{300}$th to the $\frac{1}{400}$th of a line in diameter, which are then contained in their interior, be of a peculiar nature, or belong to the epithelium, is doubtful. With the advance of spring, the testes gradually increase in size, and at length are found of twenty, and even thirty times the size and weight they possessed in the depth of winter[27]. The seminal

[25] Refer back to the observations on the preceding paragraph (§ 8) Annot. 20, 21, 22.

[26] It seemed to be perfectly indifferent in what manner the animals were killed whose seminal animalcules I wished to examine; dogs, rabbits, birds, &c. poisoned with strychnine, coniine, &c., the irritability of whose muscular nerves was entirely gone, still afforded me spermatozoa possessed of all their activity, which lasted as long, too, as under any other circumstances.

[27] The testicles become of extraordinary magnitude, both absolutely and in relation to the rest of the body, in the duck, and in the common fowl; in the passeres, or singing birds, I also find them very remarkably developed, and the left testis generally more so than the right. On this subject see my *Elements of Comparative Anatomy (Lehrb. der vergleichenden Anatomie,* S. 248), and my *Contributions to the Anatomy of Birds (Beiträge zur Anatomie der Vögel),* in the *Abhandlungen der Baierischen Akademie,* Bd. II. S. 284. The progressive enlargement of the testis in birds as the pairing time approached, was studied by Mr.

vessels expand greatly and form thick convolutions like those of the brain, visible to the naked eye, and glistering through the proper capsule of the testis, which is now covered with a network of arteries and veins. At first, granules and globules of different sizes and forms, either more darkly granular, or pale with several larger molecules included, and frequently with only a single larger granule in the centre, are discovered (fig. V. *a*, *b*). These cor-

Hunter (vide *Animal Œconomy*, ed. by Owen, 1837, 8vo), and plans of their relative dimensions in the House-sparrow at different seasons, are given by Owen in his article Aves in Todd's *Cyclopædia*, vol. I. p. 354.

Fig V.

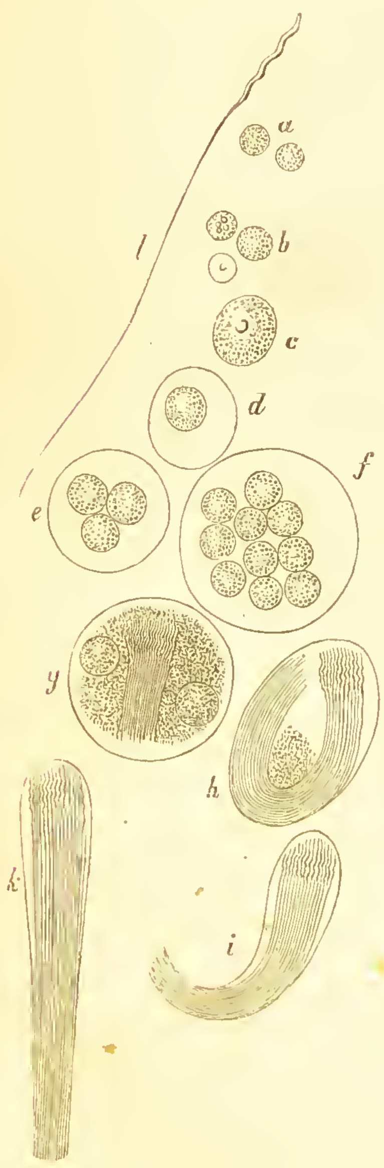

Fig. V.—This fig. represents the several stages of evolution of the spermatic animalcules of *certhia familiaris* (common creeper). As a greater degree of force has been given to the outline than is to be met with in nature, the figure rather resembles a plan than an exact copy of what may be observed. The objects are delineated as magnified from nine hundred to one thousand times:—*l*, an adult spermatozoon taken from the orifice of the vas deferens; *a*, seminal granules, taken from a very collapsed testicle in the winter season; *b*—*k*, several seminal granules, taken from a testicle in summer, during turgescence; *b*, *c*, seminal granules, which are probably nothing more than altered epithelial cells; *d*, *e*, *f*, cysts or vesicles, enclosing one or more round granular globules; *g*, a similar cyst, containing, besides the two globules, a finely granular mass, in which the spermatozoa may be seen to form; *h*, the cyst, still containing some finely granular matter, has assumed an oval form, and the bundle of spermatic animalcules, increased in size, lies bent up within it; *i*, a cyst still more developed, the involucrum, pear-shaped, covers the bundle of animalcules where their spiral extremities lie; *k*, a cyst arrived at maturity, still covered by the involucrum.

puscules or globules are from the $\frac{1}{200}$th to the $\frac{1}{300}$th of a line in diameter. One of the larger darker globules, with evident traces of a central nucleus, is here represented (fig. V. *c*). Whether these globules are new elements, or altered epithelium-cells, it is difficult to determine. No less so is it to say whether they undergo transformation or evolution in the manner of the bodies next to be described, by assuming a covering, or expanding bladderwise involved in a dense tunica propria. Along with these bodies, and in connexion with the increasing afflux of blood, and augmenting turgescence of the testes, there are evolved numbers of distinctly rounded and perfectly transparent vesicles, which at first present one (fig. V. *d*), and then several,—two, three, four (*e*), and as many as ten and more nuclei. These nuclei are delicate, pale, (in the figure they are too dark and hard,) granulated globules, bearing a partial resemblance to the finer globules (*a*) first described. The vesicles, or replete globules, now under consideration, grow from the $\frac{1}{150}$th to the $\frac{1}{100}$th, and finally to the $\frac{1}{50}$th of a line in diameter. In the course of their development a fine granular precipitate is observed to form between the included nuclei, by which these are first obscured and then made to disappear, and linear groupings are produced, which anon proclaim themselves as bundles of spermatozoa, already recognizable by slight traces of a spiral formation of one extremity (fig. V. *g*). It were hard to say whether the finely granular precipitate is to be regarded as the product of a process of resolution occurring to the nuclei, or a new formation, as also, whether the spermatozoa spring out of, or only in and amidst this yolk-like matter, or matter that at all events is comparable to the yolk of eggs in general. The vesicles now assume an oval form (fig. V. *h*), the globules disappear, the granular contents diminish; the seminal animalcules are well-grown, and lie bent up within the cyst; their spiral ends are more conspicuous. The delicate covering (involucrum) is now drawn more closely around the bundle of spermatozoa it includes, and where it covers their spiral ends anteriorly it assumes a pyriform outline (*i*), and at the opposite extremity is perhaps at this time open; but it is difficult to speak decisively on this point. The cysts are now very commonly bent nearly at right angles, or like knees; but at length they appear stretched out and straight, and have attained their full size (*k*). The capsules of these vesicles are at all times, and especially towards the end of their existence, highly hygroscopic; the addition of a little water causes them to burst, the masses of spermatozoa, rolled up like a little skein of thread or silk, escape, and occasionally at this stage exhibit motions individually, which, how-

ever, whilst the animalcules continue in the ducts of the testes, are frequently not to be observed, and are never either general or remarkable. The spermatozoa, after the rupture of the cyst, advance in freedom to the vas deferens, where they become stronger, and commonly look as if they were better nourished (fig. I.); severally the spermatozoa are here about the $\frac{1}{30}$th of a line in length, and the fully developed cysts and bundles (fig. V. *k*) in the testicle have the same dimensions; it is at this period that, from their lying many together, they can be most easily followed to their smaller ends, and most advantageously subjected to micrometric admeasurement. The spermatozoa of the finches (fringillidæ) are extremely large, particularly in the bullfinch, where they are as much as the $\frac{1}{6}$th of a line in length (fig. IV. *b*). In other families, as in the laniadæ, they remain much shorter; they are still shorter and far more globular in all the remaining families of the class [28]. It is equally easy to follow the several steps in the development of the spermatozoa in cysts and vesicles among the frog tribes; but more difficult to observe them in the mammalia and man; in whom, nevertheless, precisely similar bodies, and what may be called vesicles of evolution, present themselves (fig. II. *a*, *b*, from the human subject), as also aggregated bundles or skeins of spermatozoa (fig. II. *c*), the covering of which appears to be of extraordinary delicacy. Besides these granules, vesicles and bundles of spermatozoa, and intermingled with them numerous scales of epithelium are conspicuous, and not unfrequently oil-globules in greater or smaller numbers (fig. VI.) And then there is the liquor

[28] On the development of the spermatozoa in the yellow-hammer, similar in every particular to that in birds generally, vide my paper in Müller's *Archiv* für 1836, S. 225, and of those of the pigeon, vide my *Fragments on the Physiology of Generation (Fragmente zur Physiologie der Zeugung*, Tab. I. S. 388). In the mammalia, amphibia, &c. I have rather frequently found spermatozoa in the testis endowed with the capacity of motion to a considerable degree.

Fig. VI.

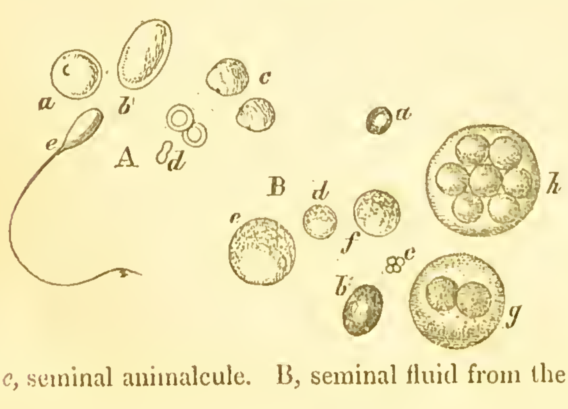

Fig. VI.—Seminal fluid of the rabbit:—A, from the vas deferens; *a* and *b*, two pale, flat, finely granular bodies, which, I take it, are merely epithelial scales; *c*, two bodies, more opaque, and having darker outlines, which I regard as true seminal granules; *d*, *d*, blood-globules for contrast, one is seen edgewise; *e*, seminal animalcule. B, seminal fluid from the testis:—*a* and *b*, two very dark

seminis as the vehicle of the whole. This is now a perfectly transparent crystalline fluid; and again it is turbid, and crowded with excessively minute molecules, very similar to the fovilla of the pollen-granules of plants. These delicate pale molecules, which are under the $\frac{1}{1000}$th of a line in diameter, exhibit the common molecular movement [29].

§ 11. The spermatozoa of the mammalia in the rutting season, and of young animals in general when they become capable of reproduction—man as he attains puberty inclusive—are developed precisely in the same manner as in birds at the pairing time. A larger quantity of blood is sent to the testes, these organs enlarge, the parietes of the seminal canals become thicker, the diameter of their area increases, and they are distended with granules; by and by the cysts or cells with their included globules as

[29] In reviewing the history of the evolution of the spermatozoa now given, in connexion with the discoveries of Schleiden and Schwann on the development of vegetables and animals alike from cells (see farther on this subject under our head of DEVELOPMENT), the idea presents itself to the mind whether the liquor seminis is not to be regarded as a "matrix" (Zellenkeimstoff, Cytoblastema, *Schwann),* in which the granular nuclei are developed as *cytoblasts*, which again put forth their covering or cyst as a cellular wall: the finely granular contents would then have to be considered as the *cell-fluid.* The cytoblasts disappear so soon as the spermatozoa are evolved in their contents, and the cells burst and cast out the animalcules as the cells of the algæ scatter abroad their sporules. It would be desirable to inquire farther into this matter, and endeavour to discover whether the cell-nuclei, or globules of the vesicles, also contain corpuscules as nuclei in their interior, which they very obviously appear to do occasionally, (fig. VII.)

and well defined bodies, which I imagine to be oil-globules; *c, c*, a cluster of four much smaller, but very well defined corpuscles, probably also oil-globules; *d* and *e*, two pale granular bodies of different sizes, either seminal granules or epithelial scales; *f*, another body of the same kind, but darker; *g* and *h*, evolution globules or cysts, with a number of extremely pale globules and some granular matter included. [Dr. John Davy, in the testes of man, invariably found extremely minute dense spherules, which he conjectures to be the ova of the spermatozoa. *Researches*, v. i. p. 332. R. W.]

FIG. VII.

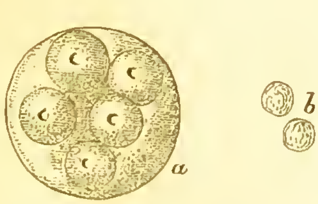

Fig. VII.—A very large cyst or bladder of evolution, containing five extremely pale globules, each of which exhibits a very minute dark nucleus. This appearance is extremely rare; it was met with in the seminal fluid of the *lanius ruficeps; b*, two seminal granules from the vas deferens.

nuclei make their appearance, and in these the spermatozoa are evolved[30].

The spermatozoa attain their highest development and motility in the excretory duct or epididymis [31]. So also in very advanced age, or as a consequence of local or general disease, and among animals living in a state of nature at all seasons save that of rutting, we commonly find the vasa deferentia empty and contracted[32], the seminal vessels of the testes small and only containing granules and here and there a globule of fat. This retrogressive process may likewise be very readily followed step by step among the tribe of singing-birds (passeres). After one or two broods have been hatched in the spring, about the middle or end of summer the

[30] It is thus that they occur in lads at the age of puberty, in young mammalia generally, and in birds. In the rabbit the spermatozoa are developed at a very early age: by the end of the third month from birth they are found to have attained complete maturity. In the dog and cat they are only developed at a much later period.

[31] This circumstance already alluded to oftener than once, namely, the more perfect development of the spermatozoa in the epididymis and vas deferens than in the testis, can only be fully appreciated on a careful inspection of these animalcules; properly speaking, they are not perhaps absolutely larger, but they are more distinct and plump, presenting a sharper outline, and looking altogether as if they were better nourished.

[32] In men in the flower of their age, and in animals during their season of heat, the capacity of the vas deferens is increased, its walls are attenuated, and the spermatic fluid escapes, or is readily pressed out from its interior when it is cut across, in the shape of a milk-white drop of fluid. In men between sixty and seventy years of age, I have still found spermatozoa in the seminal canals of the testicle; in the vas deferens they were not numerous; in the vesiculæ seminales they seemed to be in the ordinary numbers. The walls of the vas deferens in old age acquire an almost cartilaginous degree of hardness, the diameter of its canal is much reduced, or nearly obliterated; in some cases the walls appeared actually to have coalesced. It is very commonly reported that exhausting diseases, and mental emotions of a depressing kind when long-continued, cause a disappearance of the seminal animalcules. But I have found them very rife under such circumstances: they occur in abundance in cases of confirmed phthisis, and in subjects worn out with hectic fever; they are always abundant in individuals who have died by the hand of justice, as well as in those who have laid violent hands on themselves. I do not know whether or not they are wanting after violent nervous attacks, after typhus, tabes dorsalis, &c.; a point which would be interesting to ascertain In one case of a youthful and strong man, in which the testicle had been extirpated on account of disease, I failed to discover any spermatozoa, although by the side of the abscesses and fistulous passages there were many perfectly healthy portions of the testis remaining, with the seminal ducts quite normal. I have also occasionally missed spermatozoa in the proper passages of aged, much emaciated, and sickly dogs. Dr. John Davy, in eighteen out of twenty cases, found spermatozoa in the dead bodies of men who had died of very different diseases. (*Edinb. Med. and Surg. Journ.* vol. 50. p. 1.)

moulting season begins; at this time the testicles have already very much contracted, and they become smaller every day. The vasa deferentia, the ends of which formed club-shaped masses by the side of or behind the cloaca at an earlier period little inferior in size to the testes themselves, still contain seminal fluid in small quantity; but the spermatozoa are motionless and pining; their spiral-shaped ends are still distinguishable, but the windings appear more like knots. In the testes the nucleated vesicles or evolution-globules are very few in number, and by and by disappear entirely; the smaller granules, and the bodies which are perhaps to be regarded as altered epithelial cells, are still present, and among them a certain number of obviously shrivelled cysts, in which the spermatozoa appear to have suffered an arrest of development, and never to have come to maturity, as if they had been produced unnecessarily and were never to be used; the spermatozoa in these do not now lie in masses or bundles, but singly, apart, altered in character, and only partially exhibiting the spiral extremity; mixed with the spermatozoa there are also certain yellowish globules, which refract the light powerfully, molecules about the $\frac{1}{800}$th of a line in diameter, and not unlike oil-globules in appearance. Somewhat later, these cysts, now plainly involved in the general degeneration, are no longer to be found, but in their stead, and perhaps proceeding out of them, certain globular or oval bodies, from the $\frac{1}{100}$th to the $\frac{1}{150}$th of a line in diameter, and aggregates of large dark round-shaped molecules or granules, now and then with a somewhat clearer nucleus, which are comparable in some sort with the large pigmentary aggregates or bodies that occur in the choroid coat of the eye. In the testis itself there is no more trace of spermatozoa to be found, than in the vas deferens[33].

[33] I have not thought proper to follow out the history of the decay or degeneration of the spermatozoa with the same extent of detail as that of their development, so that their states at various intermediate times are not noticed, and perhaps other particulars not without interest are overlooked. The crow and magpie were the principal subjects of my observations in this part of the inquiry, and it is from these that the particulars in the text are given. It is to be understood of course that all the facts there set down were not observed in the precise order in which they appear, that the account rendered of them is always an epitome of many isolated observations, and even connected and completed in parts by analogy; though individual adventitious points may be called in question, and my explanations of others may even be shown to be erroneous, I still believe nevertheless that I can vouch for the accuracy of all that is essential. The whole of my statements rest on my own very numerous observations and researches; as weighty guarantees of their accuracy, I am happy in being able to cite Siebold (in Müller's *Archiv*, 1836, S. 436), and Valentin (in his *Repertorium*, 1837, S. 143).

§ 12. *Examination of the Male Sexual Organs of Hybrids.*

It is an universal law in natural history that animals of the same species only seek sexual intercourse spontaneously, and give birth to a fruitful progeny. It is perhaps only under some artificial influence, usually traceable to the interference of man, that animals of different species intermingle sexually: in their natural state of freedom an union of this kind certainly occurs very rarely, and it is only between generically allied animals that such a conjunction has any sequence; the *mules* or *hybrids* then produced are for the most part barren, or otherwise they are capable of procreating with one or other of the animals from which they are descended through at most one generation; two mules have very seldom been known to have fruitful intercourse; the race then dies out. This fixed law, ordained for the protection and continuance of existing kinds and species, is of the highest importance[34], and naturally leads to the question as to the state of the germ-preparing sexual organs of the males of mules, whether spermatic fluid is produced, and whether spermatozoa are present in the fluid secreted. Several isolated observations would

[34] A comprehensive general view of all the trustworthy accounts yet published in regard to hybrids of the higher animals, which have either been produced under the dominion of man, or been encountered in the natural wild state, would be of great physiological interest; particularly if a careful comparison were at the same time given of the colour, and of any peculiarities of external conformation and internal structure, the comparison being made as well between the animals of the parent stock as between the hybrids themselves. Undoubted cases of hybridism are almost only known as having occurred between animals that belong to one genus,—for example, between the wolf and the dog, the lion and tiger, the sheep and goat, the horse and ass, the horse and zebra, &c. All of these animals only communicate sexually under the influence and with the interference of man; and they are even then for the most part brought to copulate with difficulty. Exceptions to the rule of identity of genus being necessary to the production of hybrids, are of exceeding variety; still there have been cases of fruitful intercourse occurring between the goat and chamois, and even between the sheep and roe; the old tales of productive intercourse between man and animals, and between animals of extremely different kinds, are altogether unworthy of credit. Barrenness is the appanage of hybridism; they are exceptions, and extremely rare exceptions, where hybrid animals prove fruitful with individuals of the original stock. Upon this subject I beg to refer to Burdach's *Physiologie*, Bd. I. S. 511. (tom. ii. p. 182. of Jourdan's French translation,) and the excellent critical remarks on the hybrids of the genus *equus* and *ovis*, by Andrew Wagner, in Schreber's *Säugethieren*, Bd. VI. S. 185, and Bd. V. 1281 et seq On the hybrids of birds, see observations under annotation 36. Instances of the production of hybrids are also known to have occurred among amphibia, fishes, and invertebrate animals. Vide *Burdach*, loc. cit.

lead to the conclusion that the semen of the mule, at least of that proceeding from the horse and ass, contains no spermatozoa[35]. In the difficulty which is felt in these countries of procuring the mules of mammalia as subjects for a series of observations, it is more convenient and much easier to make use of the mule progeny of birds. Those that are most commonly met with are the hybrids of canary-birds, and others of the finch tribe, such as the goldfinch, gray-linnet, &c.[36] It is well known that many of these mule

[35] Hebenstreit, Bonnet, and Von Gleichen, all inform us that they had failed to discover spermatozoa in the stallion of the common mule, or hybrid between the mare and ass; Prevost and Dumas, whose observations bear the impress of accuracy and authenticity, found no trace of seminal animalcule in the whole course of the genital organs of a male mule, which was remarkable for its salaciousness; the contents of the seminal canals, of the testes, and vasa deferentia, consisted of globules only (the figures prove them to have been mere epithelial cells); in a horse and ass examined at the same time, plenty of spermatozoa were discovered. Vide their paper in *Ann. des Sciences Naturelles,* I. p. 182, and Pl. 12, C. A. M.

[36] Here also I choose birds as the subjects of my inquiries; among which decisive observations are easily and at any time repeated. It is remarkable and doubly interesting that it is among birds, and particularly gallinaceous birds, that hybrid productions occur more commonly perhaps than among all the other classes of animals put together. The number of instances increases every day in which the *tetrao tetrix* (moorfowl) and the *tetrao urogallus* (blackcock) have been found to have fruitful connexion in their natural wild state, the product of this union being the *tetrao medius,* long regarded by naturalists as a distinct species. On this subject see Naumann's *Natural History of the Birds of Germany (Naturgeschichte der Vögel Deutschlands,* B. VI. S. 304,) and Gloger's *Manual of the Natural History of the Birds of Europe (Handbuch der Naturgeschichte der Vögel Europas,* I. S. 512). In Sweden and Russia such instances seem to occur still more frequently. I had myself, very lately, a specimen from the south of Bavaria, but was unfortunately prevented from examining the sexual organs. The instances of a productive union between the *tetrao tetrix* (moorfowl) and the *tetrao lagopus* (ptarmigan) in their natural state of freedom, are of rarer occurrence; as also of the *hirundo domestica* (house-swallow) and the *hirundo agrestis* (marten), cases of which will be found recorded by Naumann and Gloger. Numerous instances have occurred of hybrids between the pheasant and common domestic fowl, as also between different members of the pheasant family with one another; these hybrids are almost always barren, occasionally only are they capable of engendering. Breeders of canary-birds have found that these creatures engender readily enough with the goldfinch, linnet, and siskin, and with greater difficulty with the greenfinch and chaffinch; whether they will procreate with the yellowhammer *(emberiza citrinella)* or not is doubtful; I find no accounts that can be depended upon on this point: if fruitful connexion did occur, it would be particularly remarkable on account of the generic difference of the kinds. In general these hybrids are barren; there are, however, undoubted instances on record in which mules, both male and female, of the gold-

birds can never be brought to pair at all; that the pairing of others, when it does take place, remains unproductive, and that some few only pair and engender. It must therefore be extremely interesting to examine the contents of the testes in such birds, to observe the changes which their sexual organs undergo in the course of the spring, and to contrast these with the corresponding parts in the original stock-birds. The male of the canary comports itself in all respects like the other passeres: the testes enlarge by degrees to rounded oval bodies of considerable magnitude, and generally of somewhat unequal size; the vasa deferentia form peculiar club-shaped convoluted masses on either side of the cloaca; the spermatozoa contained in these, as in all the other members of the finch family, are very large and strong, though somewhat less so than those of the chaffinch, and about the tenth of a line in length; their spiral end is well developed and furnished with two principal threads (fig. IV. *c*) of the screw. In the male goldfinch, every circumstance bears the same general complexion, but even the best developed of the spermatozoa are here somewhat more slender and shorter; their spiral end, too, is less strongly marked (fig. IV. *d*); they measure the $\frac{1}{15}$th of a line in length. The sexual organs of the male mule or hybrid of the male goldfinch and female canary, exhibit great diversities in the state of development of the testicles at the pairing season. In some, these organs continue extremely small; in others they enlarge in different degrees, but scarcely ever attain to more than half the size of those of the stockbird, and are always of a rounder form; they are either

finch and canary have shown themselves capable of procreation; but this was only with canary-birds, as it would appear, not with one another. I have sacrificed a considerable number of hybrids of this kind in the course of my inquiries on the subject of generation; I always found the vasa deferentia empty: in the testicles the product varied; there were either no seminal animalcules discovered or these were imperfectly developed, I imagine, however, that hybrids actually capable of engendering must produce proper spermatozoa. In female hybrids I found all the anatomical requisites to procreation; to wit, an oviduct, an ovary with numerous little yolks which all contained a germinal vesicle; I never saw ripe or ripening yolks, however. It were of the highest interest for natural history in general, as well as the physiology of generation, were an extensive and systematic series of observations, which should be varied in every possible manner, and repeated again and again, to be undertaken upon the crossings and intermixtures of our cage-birds and their hybrids. The facility with which canary-birds are reared, and the readiness with which they admit birds of other kinds to their society, seem to promise the best results in taking them as the subjects of observation. Continued researches in minute anatomy would necessarily go hand-in-hand with these observations.

developed in equal measures, or the one grows more than the other; sometimes the right, sometimes the left. In those that are best developed, the windings of the seminal canals, and the beautiful network of blood-vessels, are distinctly seen shining through the tunica propria. The fluid contained in these canals is white, and presents globules and granules of different sizes, similar to those discovered in the testes of other birds (fig. V. *a*—*c*), but the true, the proper genetic globules are always wanting. Instead of these we meet with roundish and elongated globules and bladders, from the $\frac{1}{100}$th to the $\frac{1}{40}$th of a line in length, filled internally with small dark molecules, occasionally with clear rings including bodies that look like germinal vesicles; many of these corpuscules are elongated and pyriform, and inclose threads with dilated extremities; but these are never connected into regular bundles, are always less numerous, and lie irregularly between or among the molecules, which are darker and larger than in the granular matter of the genuine cyst of the seminal animalcule. These formations seem to depend on and to denote an imperfect production of spermatozoa, which are entirely wanting in many mules; when they do occur, they are always at the best smaller than those of the stock-bird, measuring the twenty-fifth, at the very most the twentieth of a line in length. Their thicker end is irregularly formed, now club-shaped, and again and more commonly elongated or bent at the point (fig. IV. *e*); they never exhibit the characteristic cork-screw spiral. The vasa deferentia of mules always remain comparatively empty, even when the testicles acquire considerable size; sometimes they are altogether wanting; in cases in which they are most largely developed, their club-shaped convoluted extremities in connexion with the cloaca, are relatively of insignificant size, and their contents consist of granules and larger globules, similar to those of the testicle, and as much as the $\frac{1}{100}$th of a line in diameter; of dimensions therefore that are never seen in other perfect birds. Proper spermatozoa, even of the insufficient size and imperfect forms of those described as occurring in the testicle, are never to be discovered in the efferent duct.

§ 13. If we now place the particulars that have been mentioned in the preceding account of spermatozoa under general points of view, the following are the conclusions that, in the present state of inquiry, may be come to:—1, spermatozoa are essential elements of the spermatic fluid, and always exist in the semen that is capable of engendering, during the whole of the limited and periodically returning season of heat among animals in general, in man and

many domestic animals during the period of their highest bodily perfection (vide § 5) ; 2, spermatozoa form the principal mass of the semen perfectly elaborated (§ 3) ; 3, spermatozoa exhibit diversities of magnitude and form that are constant, among which certain general types in relation with the several classes, orders, and families of animals are not to be overlooked, and which in numerous cases are characteristic in regard to the individual species (§ 5) ; 4, in one and the same species of animal, and in the same individual, no more than one determinate form of spermatozoon is ever encountered ; 5, nothing like a determinate internal organization can yet be said to have been certainly discovered in any spermatozoon (§ 6) ; 6, the motions of the spermatozoa are extremely various, and throughout bear the character of volition (§ 7) ; 7, the continuance of the motions, the influence of different fluids, of temperature, and so on, vouch for an independent life in the spermatozoa, which is only dependent in a certain degree, more or less, on that of the animal in which they are found (§ 9) ; 8, their mode of development is cyclic, and occurs in harmony with the general laws of animal development, with especial modifications, and having certain analogies, to that, namely, of the cercaria and entozoa (§ 10) ; 9, as a rule, hybrids produce no genuine spermatozoa (§ 12). As a general conclusion, it may be stated, that spermatozoa are essential elements of the seminal fluid, and bear a specific relation to the generative act ; they are so far comparable to the blood-globules, which present themselves in the same manner as essential typically organized constituents of the blood amid the liquor sanguinis, just as the spermatozoa present themselves amid the liquor seminis. Whether they are really animals or not cannot now be determined with absolute certainty, inasmuch as the chief criterion of animality—an internal organization, an alimentary apparatus, &c.—has not up to the present time been satisfactorily demonstrated ; their independent motions and mode of development, however, speak for their animal nature. The views hitherto entertained in regard to the spermatozoa, that they are mere parasites, accidental entozoa, collateral effects of the reproductive power, &c., are unlikely and hardly tenable. But whether their formation may be most readily explained by the hypothesis of equivocal generation, or by that of parental reproduction—admitting them to be true animals—is at present doubtful [37].

[37] These conclusions follow as consequences from the observations and facts adduced in the preceding paragraphs of the text. I cannot, therefore, in any way assent to the views of Burdach and Baër, according to which the formation of

§ 14. *Physical and Chemical Analysis of the Spermatic Fluid.*

The accounts we have of the physical peculiarities and chemical constitution of the spermatic fluid are for the most part either erroneous or defective, inasmuch as it has hardly yet been examined in a state of entire purity; indeed it is hardly possible to procure it without any admixture of mucus and epithelial scales[38]. In its normal state it is a thick, tenacious, whitish, grayish, or slightly yellowish coloured fluid; it is heavier than water, and forms an emulsion when shaken up with it. The peculiar odour usually described as belonging to the spermatic fluid, and which is commonly likened to that of grated bones, most probably inheres in one or other of the fluids with which it is mingled at the moment of ejaculation; the pure seminal fluid both of man and animals appears to have no decided or peculiar odour[39]. Normally the

the spermatozoa is a mere collateral effect of the reproductive power, an entozoic genesis, which occurs most abundantly in the spermatic fluid, because this among all the organic matters and secretions is endowed with the highest amount of plasticity. The decision of the question as to the mode of production of the spermatozoa, whether it is *parental* and from others like themselves, or *equivocal*, does not involve aught of peculiar interest as regards them in a physiological point of view. I allow that the late researches of Ehrenberg and of Schwann, and to theirs I may add my own, take away almost every support from the assumption of an equivocal generation in regard to any class of animals whatsoever; with regard to the Infusoria in particular, I now declare myself entirely of the opinion of Ehrenberg. All inquiry has hitherto failed to discover in what manner the entozoa originate. It seems impossible that their ova can be transported by the circulation and deposited in determinate places suitable for their evolution; the ripe ova of the smallest human entozoa are much larger than the smallest capillary vessel; the smallest ova I have observed are those of the tænia solium ($\frac{1}{80}$th of a line in diameter), of the trichocephalus dispar ($\frac{1}{50}$th of a line in diameter), and of the ascaris vermicularis ($\frac{1}{10}$th of a line in diameter), and the diameter of the finer capillaries varies from the $\frac{1}{150}$th to the $\frac{1}{300}$th of a line in diameter. Various hypotheses might be started in regard to the genesis of the spermatozoa, and supported with various reasonings; upon this subject, as also on that of equivocal generation, I refer to the *General Physiology*. (Book IV.)

[38] All existing analyses of animal substances have little value, partly because of the manner in which they are usually reported, partly because of the imperfection of the elementary analyses, and partly also, and this applies particularly to the semen, the blood, &c., because a great variety of most heterogeneous principles, which ought to be separated from one another, and reported on severally, are blended together, and the composition of all is given under one category. Microscopical analysis ought henceforth to go hand-in-hand with that which is purely chemical.

[39] I have seldom perceived any peculiar smell from pure spermatic fluid, and believe that in many cases the secretions of the vesiculæ seminales, of the prostate,

spermatic fluid shows weak alkaline reaction, and when dried and burned it exhales an ammoniacal smell; the ammonia, however, is a product of the decomposition, and is only formed at the moment this takes place. Chemical analysis shows it to consist of albumen, phosphatic and hydrochloric salts, and a peculiar animal matter called *spermatine*. No kind of crystal is ever found in fresh semen; it is only in such as has stood long that salts are formed and deposited in crystals, which on examination are usually found to consist of phosphate of lime[40].

§ 15. *Microscopic Analysis of the Ovum.*

The place of formation of the OVA, through the whole animal series, is the ovarium or female *testis*, as it used to be styled by the older writers. The OVARIA, in the vertebrata, consist of a more or less condensed cellular tissue, which not uncommonly exhibits a coarsely fibrous texture, in the interstices of which the ova, more or less crowded together, are imbedded in large round cells (fig. VIII.). This nidus, or stroma, is in general

of Cowper's glands, and of the other accessory secerning apparatus, which is often so largely developed, give rise to the peculiar odour, often of a very penetrating kind, in the horse for example, which is remarked as belonging to ejaculated semen.

[40] On the peculiar properties and chemical analysis of the spermatic fluid, see Burdach, op. cit. I. 110, Berzelius's *Elements of Animal Chemistry (Lehrb. der thierischen Chemie*, übers. von Wöhler, 1831, S. 522), and Thomson in Todd's *Cyclopædia*, II. 458. In the human spermatic fluid Vauquelin found ninety parts of water, one of soda, three of phosphate of lime, traces of muriate of lime, and six of a peculiar substance (spermatine?). These substances Lassaigne also detected in the spermatic fluid of the horse, and in addition, muriate of magnesia, and muriate of soda and of potash; Fourcroy and Vauquelin met with precisely similar elements in the sperma of fishes, and farther phosphorus. Gleichen paid particular attention to the crystals that occur in the seminal fluid, and in his work quoted above, tab. II., he has given representations of those he met with in that of the human subject.

FIG. VIII.

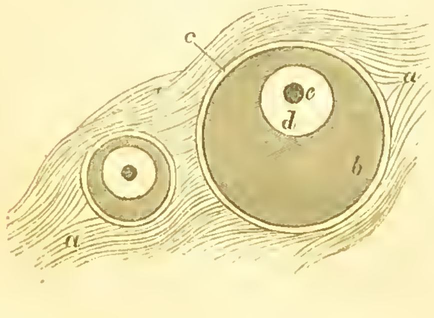

FIG. VIII.—Primary ova of the bird, magnified; scarcely to be seen by the naked eye:—*a*, stroma, or substance of the ovary, composed of thick fibres; *c*, chorion, or theca of the ovum, so thick as to be seen in the guise of a ring; *b*, yolk; *d*, germinal vesicle; *e*, germinal spot. The structure of the smaller ovum is the same.

much more delicate in the invertebrate series, and the little ovules, in closely packed masses, fill various small blind ducts, of the aggregation of which the ovaries consist. Immediately around the cell where the ovum lies, there are networks of blood-vessels, which enter the theca or capsule which includes each individual egg, and are ever the more conspicuous the larger and riper the egg is (fig. XXIV. *b, c*) [41].

§ 16. The OVUM still included in the ovary consists of the following essential parts, which are presented more or less conspicuously even in those of the smallest size :—1st, an external transparent tunic [chorion ?], without perceptible structure, and unfurnished with blood-vessels, but very generally throughout the vertebrate series of animals connected with the ovary by a particular external lamina composed of the cellular tissue of the surrounding nidus and of blood-vessels—the capsule or theca of the ovum (fig. VIII. *c*) [42]; 2nd, of the vitellus, or vitelline globule, the proper contents of which are very generally transparent and developed in very moderate quantity in the smaller ova, but subsequently much increased by the assumption of new matter, and separated into different elements; even at a very early period there is formed around the vitellus or yolk a peculiar, exceedingly delicate membrane without perceptible structure—the vitelline membrane (fig. VIII. *b*); 3d, of a perfectly spherical transparent vesicle, sunk amidst the vitellus—the germinal vesicle—*vesicula prolifera* s. *germinativa*, which, besides a perfectly colourless fluid, contains one or more dark corpuscules, that appear as nuclei through the including membrane in the shape of opaque spots—the GERMINAL SPOT —*macula germinativa* (fig VIII. *d, e*) [43].

§ 17. The VITELLUS or YOLK in almost all the less forward ova

[41] For a particular account of the form and structure of the ovaria in the animal kingdom generally, see my *Elements of Comparative Anatomy (Handbuch der vergleichenden Anatomie)*, and the paragraphs that follow.

[42] To obtain conviction of the existence of this transparent structureless chorion [?], the ovary of one of the invertebrate animals—for instance the unio—should be selected. In the higher vertebrate animals this chorion [?] under the microscope presents itself as a ring of variable thickness; in ova more advanced it is found grown to the external vascular capsule, *theca*, (the later *calyx* of the ova of birds, amphibia, and fishes (fig. IX. *a, c*). In regard to the structure of the ova of man and the mammalia see farther on.

[43] The remarkable and prevailing similarity in the structure of the ovum through the entire series of the animal kingdom, I have made it my particular object to exhibit in my *Prodromus Historiæ Generationis*, fol. Lips. 1836. The article Ei (ovum) in Ersch and Gruber's *Encyclopædie* may also be consulted with advantage, as a commentary on what has here been said.

of the various tribes of animals is a transparent colourless fluid, in which by degrees small darker granular elements are developed. With the growth of the ovum larger vitelline globules make their appearance, which are themselves filled with smaller granules or molecules, and occasionally also with a few scattered larger and darker globules; mingled with these, variable numbers of oil or fat globules may be discovered, and in addition and everywhere interposed between the vitelline globules, the albuminous colourless fluid in small quantity, which precedes the formation of the proper elements of the yolk. The elements within the several vitelline globules undergo a gradual change as the ovum continues to advance in its development. In the centre of the yolk there is a kind of space or cell which is filled with vitelline matter of a lighter colour (fig. IX. *i*) than the rest; from this there proceeds a canal filled with the same matter towards the surface, to which the germinal vesicle, having quitted the central parts of the yolk, has now also attained, where it appears imbedded in a circular layer of the yolk of a paler yellow colour, known as the *discus proligerus, discus vitellinus s. stratum proligerum,* (fig. X. *b, b*). The globules of this discus proligerus, which are also filled with smaller globules, like the vitelline globules in general, are distinguishable under the microscope from those of the rest of the yolk, and it appears that the stratum of globules lying in immediate contact with the general vitelline membrane, forms a particular loosely connected layer [44].

[44] The description here given applies in particular to the yolk of the bird's egg, in which even the smallest ova are found already full of dark vitelline molecules, which rarely happens among other animals. The structure and arrangement of the elements of the vitellus form one of the most difficult subjects of microscopical investigation; it is one, therefore, which is by no means to be held as exhausted. It is especially difficult to conclude as to the

FIG. IX.

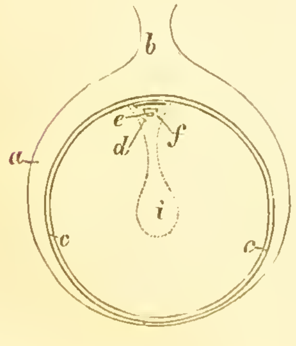

FIG. IX.—Section of a yolk almost ripe, included in its theca and calyx:—*b*, petiole or stalk connecting the calyx with the ovary: *a*, thicker substance of the calyx united with the theca of the ovum; *c*, vitellary membrane; *d*, germinal vesicle, which by and by becomes the cumulus proligerus of *Baër*; the nucleus cicatriculæ of *Pander; e*, proligerous disc; *i*, central cavity of the vitellus, its duct proceeding upwards.

§ 18. The GERMINAL VESICLE[45] is very large, and in relation to the whole mass highly developed in the smallest ova; it not un-

relationship between the finer molecules and the vitelline globules and their envelopes, between the oil-globules and the vitelline globules, and so on. The molecules, which exhibit lively molecular motions when the vitelline globules are burst, are partly of excessive minuteness, and appear, even out of the globules, to be suspended in vitelline matter. Baer describes the elements of the vitellus of yolk in the following terms :—"The granules, upon which the yellow colour of the substance of the yolk depends, are of different kinds. Some are larger and pretty regularly globular; they have a diameter from the 0,005th to the 0,0125th of a line, and themselves consist of still smaller less dissevered granules. In far greater numbers appear a countless multitude of granules, of such minuteness, that even under a high magnifying power they only show as points, without any distinctly determinable forms. Between these granules in point of dimensions there are others, clearer masses, the shape of which is not regularly round, but generally elongated, which, despite their clearness, observers agree in supposing not to be hollow vesicles, in which case they would also be more regular in their form. These bodies are not to be confounded with the glancing clear oil-globules which are always met with as elements of the yolk, and look much more like small pieces of albumen. There is still a fourth kind of corpuscule, of a round figure, smaller than the sort first described, and containing in its interior a small round granule or vesicle; this fourth kind of body is generally only encountered in the vicinity of the central cell." *History of the Evolution of Animals* (*Entwickelungsgeschichte der Thiere*, Bd. II. S. 19). Schwann has given very good representations of the yolk-globules or yolk-*cells*, such being his view of their constitution. Vide his Microscopical Researches on the uniformity in the structure and mode of growth of animals and vegetables (*Ueber die Einstimmung*, &c. S. 55, Berlin 1838). Schwann distinguishes between the globules of the vitelline cavity and those of the yolk in general. The former occur in the vitelline canal, and in the spot entitled nucleus cicatriculæ, or nucleus of the tread. They present themselves as perfectly round balls or globules with smooth margins, which contain in their interior a smaller globule with a sharp contour which resembles an oil-globule. The globules of the general substance of the yolk again are larger, their contents are granular, mostly without any smaller globule as a nucleus ; they are extremely sensitive to the action of water. Schwann believes that, except the contents of the yolk-globules, no other finely granular substance occurs free as an element of the yolk. [On this very interesting but difficult subject, see the recent work of Reichert entitled, The Life of Evolution in the Vertebrata (*Das Entwickelungsleben im Wirbelthierreich*. Berlin, 1840.) pp. 87 et sqq.]. The synonyms of the stratum proligerum are rather numerous and confusing. Baer, too, distinguishes in it the flatter, discoidal portion under the title of *discus proligerus ;* the middle portion of the same stratum, again, which is thicker, and stretches under the germinal vesicle into the yolk (fig X.), is named by Baer the *cumulus proligerus*, and by Pander the *nucleus cicatriculæ*, or *nucleus of the tread ;* I have spoken of the whole formation in my Prodromus under the name of the *discus vitellinus*. Consult § 47, where the structure of this part is described in the new-laid egg.

[45] The discoverer of the germinal vesicle is Purkinje, after whom this part has also been called the vesicula Purkinji. It is fully described by him in his *Sym-*

frequently constitutes a full half of the entire ovulum. The yolk with its including membranes then surrounds it pretty tightly. This vesicle lies at first at or near the centre of the ovulum; but in the same proportion as the yolk in general advances in its growth, the vesicle is found to approach the periphery, until it is immediately under the vitelline membrane, where it lies imbedded in the middle of the disciform granular mass named *discus proligerus* s. *vitellinus*, the subsequent *stratum proligerum*. The vesicle is sunk in a depression of the vitelline disc, but extends somewhat beyond this superiorly, and tending towards the inner aspect of the vitelline membrane (fig. X. *B*); the germinal vesicle may therefore be seen even with the naked eye in middle-sized ova, in which, generally speaking, it has already attained its full development, shining through the vitelline membrane towards the middle of the vitelline disc (fig. X. *B*). It is completely spherical, but becomes flattened in many animals, frogs among the number, at a late period[46]. It consists of a simple structureless, perfectly transparent, and extremely thin membrane, which, however, is not

bolæ ad ovi avium historiam ante incubationem, 4to. Lips. 1830, and figured in his first plate. See the comprehensive article Ei by the same writer in the *Encyclopædisches Wörterbuch*, B. X. S. 107 (1834). Representations of the germinal vesicle and macula in ova at an early period will be found in my *Prodromus*, and article Ei in Ersch and Gruber's Encyclopædia.

[46] The bedding of the germinal vesicle in a pore or depression of the *discus vitellinus* or proligerous disc, and its appearance through the vitelline membrane, are particularly conspicuous in birds, lizards, and serpents; in the riper ova of the frog the germinal vesicle appears as a relatively large flattened body, under the black vitelline or proligerous disc; to obtain a view of it, an ovulum must be opened with fine scissors, when it will generally be found to escape and become perfectly visible to the naked eye. A perpendicular section through ova that have been hardened for a short time in acetic acid, exhibits the relative positions of the parts very plainly. See my *Contributions to the History of Generation, &c.* (Beiträge tab. II. fig. 6.) The relations are similar in the salamander.

FIG. X.

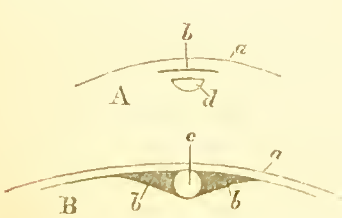

FIG. X.—*A*, ideal section of part of the yolk of a hen's egg expelled from the oviduct; *a*, vitelline membrane; *b*, germ (blastos); *d*, cumulus proligerus: these parts are represented as more remote from one another than they are in nature. *B*, ideal section of part of the yolk before its separation from the ovary; *a*, vitelline membrane; *b*, *b*, discus proligerus; *c*, germinal vesicle.

without some degree of elasticity, and a power to resist pressure that is not too violent. It is completely, and even tightly distended with a perfectly colourless and limpid fluid, the albuminous nature of which is proclaimed by its coagulating in alcohol and acids.

Besides what has now been described, in man, the mammalia, birds, the scaly amphibia, and many invertebrate animals, an opaque spot is observed upon a particular part of the germinal vesicle; this is the MACULA GERMINATIVA, the germinal spot (fig. VIII. *e*, fig. XI. *d*, figs. XV and XVI. *g*). Attentively studied, the germinal spot, even in the smallest ova, in which indeed it is often most conspicuous, presents itself as a rounded, granular formation, attached to the inner wall of the membrane of the germinal vesicle[47]. It happens not unfrequently that amidst the finely granular tissue of which the germinal spot consists, a few larger molecules may be distinguished; occasionally it has even the appearance as if it were surrounded by a delicate and closely-applied covering or capsule[48]. Under pressure, or when rolled about, the germinal vesicle assumes different forms[49]. In many animals, as for instance in naked amphibia,

[47] To gain a general idea of the structure of an ovarian ovum, one of the invertebrate animals—an anodonta, or, still better, an unio—should be chosen. Here there is no difficulty in distinguishing an outer coat, *membrana externa* s. *chorion* [?], surrounding, at a greater or less distance, the vitellus or yolk, which is to be understood as included in its own peculiar covering, the *membrana vitellina ;* the vitellus will be observed including an extremely beautiful, pellucid, and large germinal vesicle, whose figure-of-eight formed germinal macula is particularly distinct. Vide my *Prodromus,* tab. I. fig. 5. In the ova of the spider and snail, the structure is also very distinct.

[48] The germinal macula appears in many animals to be surrounded by a particular covering, a circumstance which I have often remarked in spiders, but which I have seen with unusual plainness in julus.

[49] I have succeeded in pressing the germinal macula as a pulpy or semiconsistent body into different shapes, with more than usual ease, in the ova of lepidoptera. Vide *Prodromus,* tab. II. fig. 22.

FIG. XI.

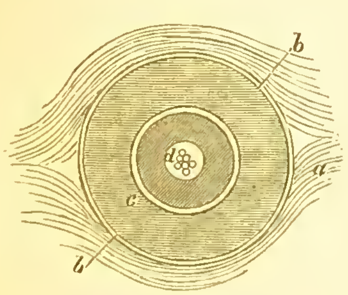

FIG. XI.—Section of an immature ovum of the rabbit, which may be compared with fig. VIII; *a, a,* stroma; *b, b,* Graafian vesicle, in its centre the ovulum *c,* and in the centre of this again the germinal vesicle *d,* in which the germinal spot, constituted by a congeries of granules, is situated.

the bony fishes, and several of the invertebrate series, a considerable number, often as many as from eight to ten dark round maculæ may be seen in the germinal vesicle of even the smallest ova, as the optical expression of certain small globular-shaped formations, attached to the inner aspect of the paries of the vesicle through its whole extent. These maculæ are of a somewhat more sluggish or oleaginous consistency than the germinal macula itself in other cases, and it frequently enough occurs that among them one larger, more opaque, and granular-looking body can be distinguished, which perhaps were correctly viewed as the true macula germinativa[50]. Even in those cases where the germinal macula never occurs save singly, numbers of new granulations in the shape of small dispersed globules may be occasionally observed in the smaller ova, and almost invariably in those that are farther advanced, produced upon the inner wall of the germinal vesicle, by the growth of which the originally larger, more conspicuous, and more opaque germinal macula is rendered indistinct or totally obscured[51].

§ 19. It is extremely difficult to speak decidedly with regard to the successive formation of the several elements of the ovum, as these are described in the preceding paragraphs. A general comparison of the formation of ova in the animal kingdom, shows that the germinal vesicle and macula are the parts which soonest attain their complete development; in insects it even seems that in the first instance these two elements only are produced, and that the vitellus or yolk is deposited around them at a subsequent period. In general, too, the external velamina or covering—the chorion or general envelope of the ovum, and the vitellary membrane or special envelope of the yolk—are encountered at a very early period, as also a very small quantity of vitellary matter; but the germinal vesicle still forms the principal part of the ovum[52]. Occasionally

[50] To observe this formation as it appears of numerous rounded germinal maculæ, let the ovary of a frog or fish, or cray-fish, be chosen. Vide *Prodromus*, fig. xvi, xxv, and xxvi. In the trout, and others of the salmonidæ, I have frequently discovered a larger macula, or body of a different appearance, which was perhaps the proper germinal macula.

[51] Examples of this will be found in the *Prodromus*, fig. xxiv. and xxvii.

[52] Examples of this kind, in which the yolk is still very slightly developed, and the germinal vesicle composes the principal part of the ovum, may be seen in my *Prodromus*, in the asterias, for instance (fig. III.); and, again, in insects, fishes, and even frogs. The successive development of the several parts of the ovum can be very advantageously studied in the tubular ovaria of insects; in the agrion, for example, tab. II. fig. 1, of my *Beiträge*. Still, even in the smallest of these ova, the vitellus or vitellary vesicle is to be distinguished as a cover-

it seems as if even in the ovary there were a small quantity of albumen formed between the chorion [?] and vitellary membrane, namely, at that point where the chorion with the whole ovum is about to pass from the ovary into the oviduct, uterus, or particular receptacle of the ova [53]. In those cases, however, in which the chorion [?], as in the ovipositing vertebrata, is connected with the outer capsule formed of the stroma or substance of the ovary, and remains behind under the name of the calyx, after the escape of the ovum, the albumen is always secreted subsequently in the oviduct, in the course of which it accumulates around and includes the vitellus [54]. The germinal vesicle may be viewed as a cell—as the primary cell—of which the germinal spot forms the nucleus; so that it would perhaps be well to style the germinal spot the germinal nucleus — *nucleus germinativus.* This nucleus disappears when new granulations are evolved in the contents of the cell (the fluid of the germinal vesicle). The primary cell lies within another cell, the vitellary cell, the contents of which in their turn become filled with new cells—the vitellary globules. The outermost cell, in which both of these principal cells are included, would then be the chorion [?] and the ovarian capsule or theca [55].

ing or envelope to the germinal vesicle. Whether the annular formations having a nucleus in their interior, which lie one behind another in the fine capillary terminations of the ovaria, are to be considered as germinal vesicles, or not, is a question still undecided. See the account of these in the proper place. [It may here be mentioned, that the observations of Dr. Martin Barry confirm the opinion that the germinal vesicle is the primitive portion of the ovum. The conclusions of this able observer will be mentioned further on. Vide his *Researches in Embryology*, Phil. Trans. 1838, p. 308. R. B. T.]

[53] This at least appears to be the case in the mytilacea: if the ova of these animals be put into water, a space of greater or less extent is discovered between the vitellus and the chorion [?], which is perhaps occupied with albumen. Vide *Prodromus*, fig. V.

[54] The formation of the albumen in the oviduct is very easily followed in the class of birds, and will be spoken of more fully in our history of the development of the embryo.

[55] The highly ingenious views and masterly researches of Schwann, led to the above attempt to explain the different parts of the ovum, of the germinal vesicle in particular. Schwann believes that the same law must be admitted in regard to the elementary form of the animal tissues, as that which Schleiden pointed out as obtaining among vegetables. Every formation consists of cells, which have excentric nuclei, which may subsequently disappear, an event that especially happens when new cellular elements are evolved in their vicinity. The nucleus, or that which is regarded as the nucleus, is often found itself to inclose nuclear corpuscules in its interior. The membrane of these cells is often difficult to be distinguished; for example, when it is extremely thin, when the nucleus lies very

§ 20. The ovum in man and the mammalia exhibits the same general elementary structure as in other lower animals, yet with such modifications as make a separate account of it indispensable. The most remarkable peculiarity in man and the mammalia is the extraordinary minuteness even of those ova that are farthest advanced, a circumstance which depends on the very small quantity of vitellus entering into their constitution. The ripest ovum in the ovary of the human subject, and of the mammalia, generally measures no more than from the fifteenth to the twentieth part of a line in diameter; it happens very rarely indeed that they are seen so much as the tenth of a line in diameter; so that they are only to be distinguished with extreme difficulty with the naked eye; this is the reason why they were so long overlooked, or mistaken, and why it is only in very recent times that they have been studied with reference to their intimate and more delicate structure[56].

close, and so forth. In the majority of cells the nucleus is absorbed at a later period; it is only in a few that it remains as a permanent formation; in the interior of older cells younger ones are very commonly evolved. In the application of this law to the particular case of the germinal vesicle, Schwann proposes many questions, and expresses himself as in doubt whether to consider the germinal vesicle as a young cell, and the germinal macula as its nucleus, or to view the whole germinal vesicle as the nucleus of the vitelline cell. Vide Schwann, *On the Uniformity in the Structure and Mode of Growth among Animals and Vegetables,* p. 50. That the germinal vesicle is no proper nucleus, I think probable on many grounds: frequently it appears that the germinal spot, as germinal nucleus, actually contains small nucleoli. Vide *Prodromus Hist. Generat.* tab. II. fig. 30, *b.*

[56] The true discoverer of the primary ovum of mammalia is von Baer: *Epistola de Ovi Mammalium et Hominis Genesi,* 4to. Lips. 1827. It seems probable, however, that De Graaf and Prevost and Dumas had seen it previously. Von Baer was not acquainted, at the time he wrote his Epistola, with the more delicate and true structure of the ovum; he in fact assimilated the whole ovum of mammalia to the germinal vesicle of birds, &c. and mistook the granular layer of the Graafian vesicle for the vitelline or proligerous disc. [Purkinje, however, the discoverer of the germinal vesicle, expressed his doubts of the correctness of this opinion of Baer, and stated his belief that the ovulum of Baer was analogous to the yolk with its contents.—Art. Ei in *Berliner Wörterbuch.* R. B. T.] A great advance was made when the germinal vesicle was discovered in the ovum of the mammiferous animal, the fact of its existence being announced almost simultaneously by Coste (*Recherches sur la Génération des Mammifères,* 4to, Paris, 1834), and Bernhardt with the co-operation of Valentin (*Symbolæ ad Ovi Mammalium ante prægnationem,* 4to, Vratislav. 1834). The work of Bernhardt and Valentin contains at once the first accurate account and faithful representation of the structure. I was myself the first to discover the germinal macula; I also described and figured the whole ovum in its successive stages with greater care and sequence than had yet been done. Vide my *Prodromus,* and *Beiträge,* where an historical account of all the discoveries connected with the ovum of mammalia

Another remarkable peculiarity consists in the manner in which the ova are contained in the ovaria; instead of being in immediate contact, by means of their chorion, or outer envelope, with the ovarian nidus, as in other animals, they are here found included in other larger rounded cells, the GRAAFIAN VESICLES or FOLLICLES. These cells, one or more lines in diameter, lie like the capsules in the stroma or nidus of the ovaries, and glisten through the peritoneal covering of these bodies; they also not unfrequently rise above the general level of the ovary, and form globular elevations upon its surface, as is seen in the representation of the ovary of the common sow (fig. XII. *c, c, c*). If the stroma is extremely delicate or scanty, the Graafian follicles even appear as pediculated globules, a structure which occurs in the common mole, and in a still greater degree in the ornithorhynchus (fig. XIII. *a, a*), where the ovary comes to assume a strong resemblance to that of birds [57]. The

is given. See also the account in Valentin's *Handbuch der Entwickelungsgeschichte*, S. 9. and the observations of Krause in Müller's *Archiv für* 1837, S. 36. [The dates of the observations by which the existence of the germinal vesicle in the ovum of the mammifera was determined, are these :—Coste, *Recherches, &c.* Paris, 1834; Bernhardt and Valentin, *Symbolæ, &c.*, Vratislav. 1834. Wagner, *Einige Bemerkungen über das Keimbläschen*, in Müller's *Archiv*, 1835, (sent in 1834); T. W. Jones, ON THE OVA OF MAN, &c.; paper read before Royal Society 1835; Observations made Sept. 1834; printed abridged in Abstract of proceedings for the year, and in full, in Lond. Med. Gazette, 1838. R. B. T.]

[57] The ovum of the human subject differs in no respect from that of the mammalia generally. Vide *Prodromus*, fig. xxxiii. It rarely happens that we have

FIG. XII.

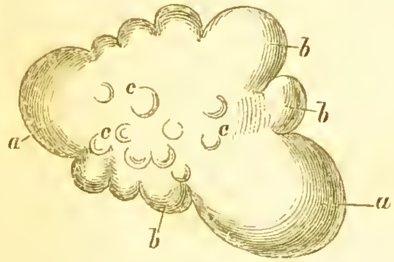

Fig. XII.—Ovarium of the sow, with corpora lutea of recent and older date: *a, a,* large reddish-purple coloured corpora lutea, about eight days after the bursting of the Graafian follicle; *b, b,* corpora lutea of later date; *c, c,* prominent mature Graafian vesicles.

FIG. XIII.

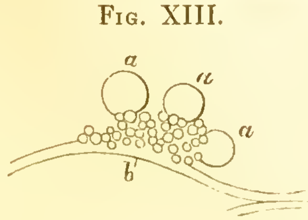

Fig. XIII.—Ovarium of the *ornithorhynchus paradoxus*, after Owen (*Philos. Trans.* 1834, pl. xxv.): *a, a, a,* three Graafian vesicles much enlarged, in consequence of impregnation; *b,* smaller unimpregnated Graafian vesicles.

Graafian vesicles consist of a double membrane, the outermost of which is extremely vascular, whilst the inner layer is velvety in appearance, from being endued with an epithelial covering. The internal space or cavity of the vesicles is very far from being filled by the ova, which are relatively much smaller; they contain, in addition, a whitish, or yellowish, thick, albuminous mass, which under the microscope appears to consist mainly of minute granules, from the 200th to the 300th of a line in diameter. These granules are generally connected by means of a tenacious fluid; they are particularly coherent in the precincts of the ovum, which is in fact imbedded in a discoidal condensed mass of these granules, precisely as the germinal vesicle is imbedded in birds and other still lower animals in the germinal or vitelline disc (fig. XV. *d, d.* figs. LXII. and LXIII. *a*). This granular disc continues attached in a greater or less degree to the ovum, when it is removed from the Graafian vesicle

an opportunity of examining a human body in so recent a state as to admit of the germinal vesicle being seen. Among the Mammalia, the cat, dog, and rabbit, are the best subjects for commencing observations upon. The Ruminantia are not so good. In the bitch the yellowish ovum may be seen shining through the peritoneal covering of the ovary and the thin membrane of the Graafian vesicle.

FIG. XIV.

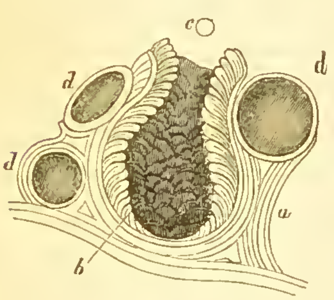

Fig. XIV.—Portion of the ovary of the *ornithorhynchus* magnified, after Owen (*Philos. Trans.* 1834. pl. xxv.): *a*, stroma of the ovary; *b*, a Graafian vesicle which has burst, and suffered its ovum (*c*) to escape (this Graafian vesicle is in the course of change into a corpus luteum); *d, d, d,* sections of entire Graafian vesicles.

FIG. XV.

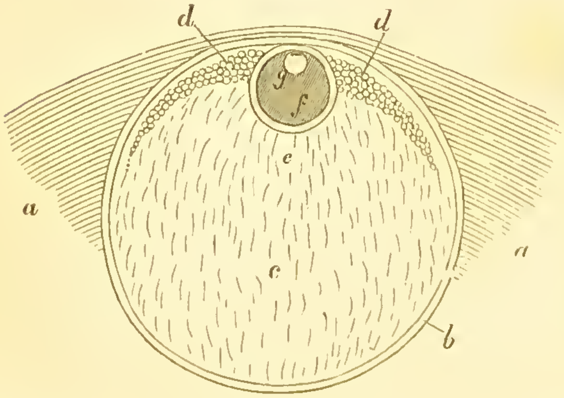

Fig. XV.—Ideal section of a ripe ovum of a mammal (the rabbit) *in situ* in the ovary: *a, a,* stroma or substance of the ovary; *b*, double tunic of the Graafian follicle; *c*, its contents, which at *d, d,* form a granular disc, in which the ovulum, *e*, is embedded; *f*, yolk; *g*, germinal vesicle with the germinal macula.

(fig. XVI. *a*, *a*; and figs. LXII. and LXIII. *a*), but the irregular and torn edges show that the appearance presented is due to violence; and, in fact, it would seem that this disc is continued as a membraniform granular layer under the inner membrane, so as to form a sort of loose, easily-rent capsule or covering to the other contents of the follicle [58]. The granules present a finely granular appearance, and are decomposed, but not very distinctly, on the addition of acetic acid to them, into a transparent envelope and a darker nucleus (fig. LXIII. *B*. *b*). In quite ripe ova (fig. LXIII. *A* and *B*) these granules may be observed as distinctly oval cells, distended with very minute molecules, and united into a membrane. If we examine this granular membrane in the bitch for instance, in ova that have begun to enlarge after impregnation, but that have not yet escaped from the Graafian follicles (fig. LXIII, *B*), the cells appear with exceedingly delicate parietes and clear nuclei, extremely like the pigmentary cells of the choroid coat of the eye. Between the granules we observe a variable number of pretty clear spaces, which are obviously due to little globules of a very pale-coloured fat or oil (fig. XVI. *b*, *b*, *b*). When still very small and immature, the ovum lies in the middle of the follicle (fig. XI. *c*); when fully formed, on the other hand, it lies immediately under the inner coat of the follicle, imbedded in its granular disc (fig. XV. *e*). To study

[58] I was long in doubt whether such an external membraniform granular layer existed or not; it was not until after Bischoff had declared his opinion in favour of its existence that I satisfied myself of its presence. Baer describes this granular layer in the second volume of his *Entwickelungsgeschichte*, p. 179, under the name of the *Körnerhaut*,—*membrana granulosa*.

Fig. XVI.

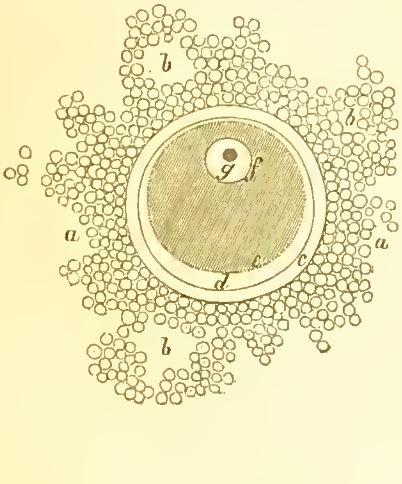

Fig. XVI.—Ripe ovum of the Rabbit, taken from the Graafian vesicle, surrounded by its proligerous disc *a*, *a*, the edges of which are ragged and irregularly notched; the clear parts, *b*, occurring among the granules, are pale oil globules; *c*, the thick chorion [?], or *zona pellucida*, surrounding the vitellus, *e*. The yolk, *e*, in this instance, is seen distinctly separated from the zona, and surrounded by a membrana propria, or perhaps an outer superficial layer of granules (the vitelline membrane? germ?); *f*, germinal vesicle; *g*, germinal spot. Vide figs. LXII. and LXIII.

the minute structure and the several parts of the ovum more particularly, a magnifying power of between three and four hundred diameters must be employed, under which, with the aid of gentle, not violent pressure, the entire structure becomes visible. The ovum is, in the first place, surrounded by a thick white ring (fig. XVI. *c*, and fig. LXII. and LXIII. *b*), which internally and externally is bounded by a simple, dark outline. This ring, by some entitled *zona pellucida*, by others regarded as a space filled with albumen [59], appears to be really nothing more than the optical expression of a thick external membrane—of the CHORION [?], in a word; it is highly dilatable, so that the clear ring it presents, appears thicker or thinner, in the same ovum, as the pressure made upon it is lessened or increased; it is perfectly transparent, and shows no trace of structure. Normally, the yolk or vitelline globule is in immediate contact with the chorion [?], but in very ripe ova it occasionally though rarely happens, that a space may be distinctly seen between the inner aspect of the chorion and the outer surface of the yolk (fig. XVI. *d*), which enlarges a little by the imbibition of water. Here, then, it is also obvious that the vitellus is bounded by a peculiar covering, a *tunica propria*, which appears to be a membraniform, external granular layer (the analogue of the *stratum proligerum* of the bird's egg? of the proper vitellary membrane?) [60].

The vitellus consists of a finely granular mass, amid which large globules, and, in thoroughly ripe ova, small clear globules of oil are scattered. The superficial layer of the vitellus appears to consist of granules larger in size and more closely compacted or united than elsewhere. Internally, that is, around the germinal vesicle, perhaps also in the centre, the vitellus is a clear albuminous-looking fluid almost devoid of granules (fig. LXII. immediately around the germinal vesicle) [61].

[59] Valentin and Bernhardt call this ring *spatium pellucidum s. zona pellucida.* Despite the positive statement of that excellent anatomist Krause (Müller's *Archiv*, 1837), that the zona pellucida is a stratum of albuminous fluid included in a distinct delicate membrane, I am obliged to say that I cannot agree with this view, supported as it is by the authority of Schwann; the rather as I find that Bischoff, who has taken great pains with this subject, entertains the same opinion as myself. In ova that have been burst, I can always trace the rent traversing it (fig. LXIII. *c*.).

[60] The space, and this is very different in different cases, between the vitellus and the chorion, is perhaps filled up by a very thin stratum of albumen. By and by, in our history of Development, this point will be investigated.

[61] This clear fluid, surrounding the germinal vesicle immediately, is distinctly

The germinal vesicle (figs. XVI. *f*; XVII. *g*; LXIII. *d*) usually appears as a clear ring, and in ripe ova lies immediately under the vitelline membrane [?] and inner wall of the chorion [?]. With a little dexterity the ovum may be burst, and the germinal vesicle forced out uninjured (fig. LXIII. *d*); it is uniformly of very small size; measuring in man and the mammalia at the most the $\frac{1}{60}$th of a line in diameter. With attentive observation the dark germinal spot is readily to be distinguished amid the clear contents of the vesicle attached to its paries, (fig. XVI. *g*, fig. LXII. and LXIII. *e*). The germinal macula is almost always seen as a simple rounded body from the $\frac{1}{200}$th to the $\frac{1}{300}$th of a line in diameter; it is very rarely observed double, or as an aggregate of granules, which, however, is sometimes the case in immature ova (fig XI. *d*). A striking difference between the disposition of the germinal vesicle in the ovum of the mammalia and that of all the other animals whatsoever, is the absence in them of a proligerous disc—discus proligerus s. vitellinus, in which, through the whole of the inferior series, it is invariably imbedded; the most careful observation shows no such structure, and no such relation here; and yet it is possible, and on analogical grounds even probable, that this discoidal accumulation of granules is not actually wanting in the ovum of man and the mammalia; perhaps the granular membrane described above, which surrounds or incloses the vitellus, generally, is the analogue of the proligerous disc [62].

It is a task of great difficulty to learn any thing of the genesis or primary production of the ovum, and to follow it through its different stages of development in man and the mammiferous animals: in very young animals, even in the embryo as it approaches maturity, we can discover ova in the ovaria, furnished with a germinal vesicle as they are at any other subsequent period of life; the vitellus is indeed much smaller, and so is the Graafian

represented in fig. LXIII; it is difficult to say whether, as in the bird's egg, it fills the central cavity of the vitellus, and is here only found in the vicinity of the germinal vesicle in consequence of the compression of the ovum.

62 Particular care ought in future researches to be taken with a view to settle this question of the presence or absence of. a germinal or vitelline disc. To me it seems highly improbable that such a relationship should actually be wanting, although the most sustained observation has hitherto shown me nothing. Connected with this, there is also the question whether or not that delicate membrane situated within the chorion [?] and bounding the vitellus, is a proper vitellary membrane, or a *stratum proligerum* surrounding the whole vitellus, in which only a certain thickening at a particular place is absent (the discus proligerus and cumulus proligerus). [See the bracketed portion of annot. 63, p. 53, signed R. W.]

vesicle, the contents of which appear to consist of larger cells, and occupy much less space than in ripe ova. (fig. XI.) The ovum with all its essential elements, however, is there, and in existence at the period of birth; very different, therefore, from the spermatic fluid, which is first eliminated possessed of its distinctive characters at the time of sexual maturity; the principal difference between a ripe and an unripe ovum lies in the greater and more especial development of the vitellus in the former[63].

[63] Embryos at the full time, or the young of some small animal, as of the mouse or rat, should be chosen for this inquiry. Carus has given a description and figure of the completely developed ovum in new-born female children (Müller's *Archiv*, 1837, p. 440, and *Ann. des Sciences Nat.* tom. vii. 1837, p. 297). [The extensive and minute researches of Dr. Martin Barry on the unimpregnated ovum require particular mention here. Dr. Barry confirms the description of previous observers as to the bilaminate structure of the Graafian vesicle. He defines this vesicle to be *an ovisac that has acquired a covering proper to itself.* The ovisac is therefore the first portion of the Graafian vesicle formed, and constitutes the internal layer of that vesicle. The formation of the ovisac, however, is subsequent to that of the germinal vesicle, which Dr. Barry, in accordance with Purkinje, Baer, and Wagner, regards as the most primitive portion of the ovum.

The early structure of the ovisac in mammalia may be seen, as Dr. Barry states, either in very young animals or in those that have lately reached maturity, when this vesicle and its contents are in the full vigour of formation. Dr. Barry finds it in young animals by placing under the microscope thin slices cut from the surface of the ovary, or, in animals after puberty, the outer portion of a large Graafian vesicle. Moderate compression is required, but it should be applied very gradually.

The first step in the formation of the ovarian ovum consists in the appearance of the germinal vesicle, which is sometimes nearly globular, at others elliptical, the long diameter then varying from the $\frac{1}{150}$th to the $\frac{1}{50}$th of a Paris line. This difference of diameter is probably owing to difference of age in the vesicles, which doubtless increase in size after their formation. The germinal vesicle at this period has an envelope consisting of certain granules of a peculiar appearance, which Dr. Barry describes as being elliptical or ellipsoidal, sometimes nearly round, and generally flattened. When lying close together, their form becomes by pressure polyhedrous. They are exceedingly transparent, yet often punctate, which latter appearance seems sometimes to arise from the presence of very minute oil-like globules. They present, with more or less distinctness, a nucleus, and two nuclei have been met with in a single granule. In the substance of the nucleus there is observable a point still darker. These peculiar granules sometimes disappear, apparently by liquefaction; preparatory to which change Dr. Barry states that he has observed them to become more spherical and brightly pellucid, seeming to contain a fluid in their interior. In size they vary from about the $\frac{1}{400}$th to the $\frac{1}{100}$th of a Paris line ($\frac{1}{4500}$th to $\frac{1}{1125}$th of an English inch), but they are often about the $\frac{1}{200}$th of a Paris line in length. As viewed by reflected light, they appear greyish white in colour; water dissolves them.

Around the germinal vesicle, then, enveloped by these peculiar granules,

§ 21. *Physical and Chemical Analysis of the Ovum.*

The yolk or vitellus, the prineipal mass of the ovum, is a thiek, sluggishly fluent, oily-looking mass, having a certain odour, often

among which are found some oil-like globules, a membrane is soon formed, which is the *ovisac;* so that the ovarian ovum, examined in this stage, consists of an ovisac containing a pellucid fluid, in which is a large quantity of the peculiar granules described, a varying quantity of oil-like globules, and among these, and more or less concealed by them, the germinal vesicle. The oil-like globules with a pellucid fluid accumulate around the germinal vesicle, between it and the peculiar granules, and thus the formation of the yolk is indicated; this new-formed yolk becomes surrounded by two membranes, one of which is the proper membrane of the yolk *(membrana vitelli)* [?], and the other, more external, is the true *chorion* [?] (fig. XVII). Subsequently, a covering or tunic, consisting of a kind of dense cellular tissue, susceptible of becoming highly vascular, and closely connected with the surrounding stroma, is gradually formed upon the outer surface of the ovisac, and it is from the union of this membrane with the ovisac that the *Graafian vesicle* results; the "couche interne" of which, as described by Baer, is the originally independent ovisac, while the "couche externe" of that author is the covering or tunic of the ovisac just described (Baer, *Lettre sur la formation de l'Œuf*, in *Breschet. Repertorium,* 1829).

The analogy between the ovarian capsule that contains the yolk in the bird and the Graafian vesicle has been long acknowledged; it was particularly indicated by T. W. Jones; and according to Dr. Barry, the ovarian calyx of birds, if deprived of its peritoneal investment, and what there is of the parenchyma of the ovary, would present a structure analogous to the Graafian vesicle of mammalia. The ovarian ovum of birds in fact passes through precisely the same stages of formation as that of the mammalia.

In reptiles and fishes the same formations are observed, and in the same order, with the exception that the fluid of the ovisac does not generally present the peculiar granules described as occurring in mammalia and birds.

The situation of the ovum in the early period of its formation is in or near the centre of the Graafian vesicle, where it is completed in all its parts, though

Fig. XVII.

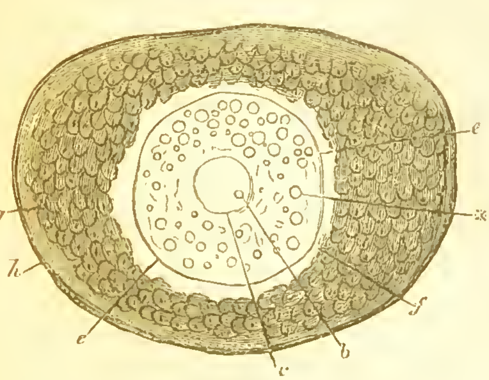

Fig. XVII.—Ovum of the cat, magnified, after Barry:—*b*, germinal spot; *c*, germinal vesicle; *, oil-like globules in the yolk, which consists besides of a pellucid fluid and minute granules; *e*, membrana vitelli [?] almost concealed by the chorion [?] *g*, peculiar granules; *h*, ovisac. [The peculiar granules, Schwann and Dr. Barry have since found to be nucleated cells. R. W.]

decided enough, but with nothing distinctly specific about it. The colour of the yolk is most usually yellow, but the shade varies

probably not matured. In this situation it appears to be supported by an equable diffusion of the peculiar granules of the ovisac throughout the fluid of the vesicle; subsequently, however, the peculiar granules become aggregated together in certain parts, leaving spaces occupied by fluid, and at length arrange themselves so as to constitute three distinct structures:—namely, 1. The *tunica granulosa*, formed by some of the granules being collected on the surface of the chorion or outer investing membrane of the ovum. These granules have been hitherto regarded as a portion of the "proligerous disc" of Baër which adheres to the ovum, and escapes with it from the Graafian vesicle. But Dr. Barry finds on attentive examination that those granules which immediately surround the ovum are in a state of denser aggregation than the rest, invest the whole surface of the ovum, and form a distinct tunic (to which he gives the name *tunica granulosa)*, perfectly spherical in form, and which he has sometimes succeeded in obtaining freed from the other granules which adherent to it escape from the Graafian vesicle. 2. The separation of the granules of the ovisac forms a layer, collected on the inner surface of the ovisac, and constituting the *membrana granulosa* of Baër. And, 3. Between the two structures just described, a third is formed, which Dr. Barry describes as "an assemblage of structures, consisting of a central mass, in which the ovum (in its granular tunic) is contained, and of cords extending from the membrana granulosa to the central mass. These structures had not been previously described, and Dr. Barry, attributing to them the office of suspending the ovum and retaining it in its situation in the fluid of the Graafian vesicle, has named them the *retinacula*. They are seen indistinctly in most animals, but may be best observed in the rabbit; their arrangement will be clearly understood by referring to the accompanying figures (figs. XVIII. and XIX.)

The office of the retinacula appears to be not only to suspend the ovum in the

Fig. XVIII.

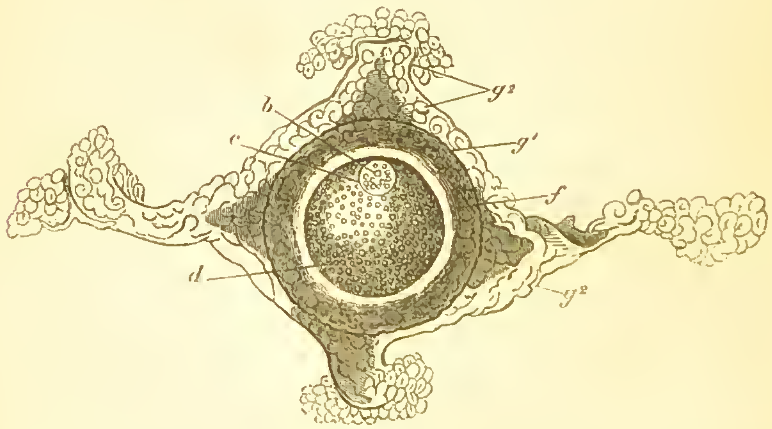

Fig. XVIII.—Ovum of the rabbit, magnified 240 diameters (after Barry). The retinacula with their membrane removed from the Graafian vesicle:—*b*, germinal spot; *c*, germinal vesicle; *d*, yolk; *f*, chorion [?]; g^1, tunica granulosa, with four tail-like processes prolonged into g^2, the retinacula.

greatly, tending more or less on the one hand to red, on the other to white; it is very commonly of a pale yellow or whitish in the

fluid of the Graafian vesicle, but to convey it from the centre, where it is at first formed, to the periphery of that vesicle, and to retain it there. This seems evident from the fact that, as the ovum approaches the periphery of the Graafian vesicle, the granulous cords become shortened on one side of the central mass, while those on the other disappear. When the ovum has reached the surface of the vesicle, the central mass in which it is contained has become smaller, and in many instances nearly of the size and form of the tunica granulosa; sometimes the band-like portions of the retinacula become reduced to four in number, and sometimes only two remain; they often seem closely pressed against the inner membrane of the Graafian vesicle. The following is the order of formation as to time of the more prominent parts of the ovum and Graafian vesicle in mammalia:—1. The germinal vesicle, with its contents. 2. An envelope, consisting of peculiar granules and oil-like globules. 3. The ovisac, which forms around this envelope. 4. The yolk, which forms within the ovisac around the germinal vesicle. 5. The proper membrane of the yolk [?], which makes its appearance while the yolk is still in an incipient state. 6. The chorion [?]. 7. The proper covering or tunic of the ovisac, the tunica granulosa, the retinacula, and the membrana granulosa. M. Barry, *Researches, &c.* pt. i. *Phil. Trans.* 1838. R. B. T.

In the preceding paragraph and the long annotation 63, the reader will have observed that the words chorion and vitelline membrane, as often as they occur, have bracketed points of interrogation placed after them, thus [?]. For more particular explanation of this, see the addition to annot. 137. Here it is indispensable to say that observers differ as to the time and mode of formation of the undoubted chorion. Some with the author, Bischoff, Dr. Barry (in his first series) &c., maintaining that the chorion exists as an original element of the ovarian ovum, its representative there, being the thick transparent membrane, or zona pellucida; whilst others, Coste, T. Wharton Jones, &c., declare that what is spoken of by Wagner, Bischoff, and Dr. Barry, as the *vitellary membrane* in the ovum of the mammal is a thing of idea and inference only, nowise demonstrable; that the peripheral globules of the ovum cohere by a vital or mechanical attraction, or at most a kind of agglutination, and are not held together in consequence of being surrounded by any membrana propria; that the zona pellucida of the mammal's ovum, as the first consistent tissue which surrounds the yolk,

FIG. XIX.

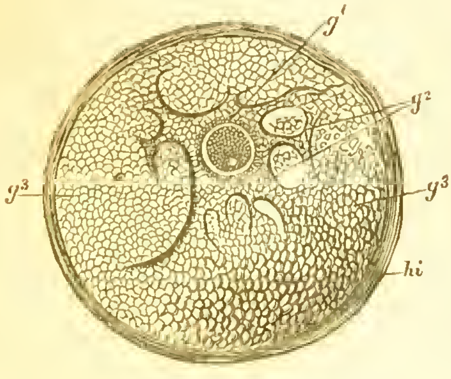

FIG. XIX.—Graafian vesicle and ovum of the rabbit, magnified 100 diameters (after Barry), to show the separation of the peculiar granules of the ovisac into three incipient structures:—g^1, tunica granulosa; g^2, the retinacula; g^3, membrana granulosa.

mammalia, amphibia, and fishes; and in many birds it is of a bright yellow, and even approaches a red: it is only among invertebrate animals that other colours, such as green, violet, blue, bright red, and flame colour are encountered; these are all, but rarely, met with, as are also brown and dark green, which, however, occur in a few instances [64]. The seat of the colour of the yolk is in the vitelline globules, not uncommonly also in the oil-globules, which are often plentifully mingled with the proper vitelline globules; in some cases the vitelline are of a very different colour from the oil-globules of the yolk [65]. The principal constituents of the yolk are water, albumen, and oil; the oil yields a crystallizable fat, which appears

ought to be regarded as the true vitellary membrane; that this zona pellucida of the ovum of the mammiferous animal is in fact the analogue of the vitelline membrane of the ovum of the bird. T. Wharton Jones was the first who saw that after impregnation in the mammal, a new structure, which he regards as the future and true chorion, is added to the ovum, even before it quits the ovary, and that the old vitellary investment, the thick transparent membrane or zona pellucida (chorion of Wagner) by and by disappears, the yolk having now the new structure for its sole membranous investment. R. W.]

[64] In many birds, the corvidæ, many palmipeds, &c. the yolk is of a very bright or reddish yellow colour; in other birds, again, it is of a pale yellow, as in the common fowl. The yolk is not very uncommonly green in insects: for example, in many butterflies it is of a beautiful grass green; so is it also among annelida in clepsine, and among crustacea in many species of cypris. It is red, according to Grant, in lobularia digitata; brick-red, according to Carus, in unio litoralis. I have found it flame-red in hydrachna histrionica, pale violet in many spiders, dark violet-blue in gammarus pulex, azure-blue in anatifa lævis; it is very frequently orange-coloured or sulphur-coloured, as in unio pictorum; milk-white, as in cyanea Lamarkii; the superficial vitelline or proligerous layer is of a blackish green in the ranidæ. There appears to be no law in regard to the colour of the vitellus in the lower classes of animals; it is frequently of the most opposite and dissimilar hues in the most closely allied genera.

[65] When the oily element of the yolk collects into distinct large drops, these may be seen, even externally, in transparent ova; the oil-globules always refract the light strongly, and are often of a colour different from the rest of the yolk. In the salmo thymallus, for example, the yolk is clear and whitish, but there is often an accumulation of reddish-yellow oil-globules, hanging together in clusters, in the vicinity of the vitelline disc; in gammarus pulex the vitelline globules included in the ovum along with the developed embryo, are large, and of a violet-blue, but the oil-globules are yellowish red; both refract powerfully. In many of the percidæ the oil of the yolk is amassed into a single large drop; and in the yolk of the emys Europea, according to Purkinje, the oil is collected into four or five distinct drops. On the chemical peculiarities of the oil of the vitellus, and indeed the whole chemical analysis of the ovum, vide Berzelius' *Animal Chemistry (Thierchemie*, 1831, p. 539). Hitherto, in undertaking a chemical analysis of the egg, there has been no attempt made to separate the oil-globules from the proper yolk globules.

to resemble that of the bile (cholestearine). Exposed to a certain degree of heat, the yolk acquires a greater degree of consistency, and under the microscope exhibits numerous rhombohedral and octohedral crystals. Incinerated, the yolk yields phosphatic salts, particularly phosphate of lime, and traces of free phosphoric acid [66]. The fluid of the germinal vesicle appears to consist of pure aqueous albumen [67].

CHAPTER II.

GENERAL MORPHOLOGY OF THE SEXUAL ORGANS.

§ 22. So far as the anatomical relations of the sexual organs can be clearly and securely followed in the organic kingdom of nature, so far do we find an obvious separation into two sexes [68]; as a general law, the male and female reproductive organs are divided between two individuals; it more rarely happens that they are united in a single individual, which then constitutes a proper normal hermaphrodite. The sexual organs are invariably parted in man and the vertebrata, and no case of true hermaphroditism appears yet to have occurred among them [69]. In the invertebrate

[66] The relative proportions of the several proximate principles of the yolk, according to Dr. Prout, are 0,17 albumen, 0,29 oil or liquid fat, 0,54 water. The ultimate principles, on the same authority, are sulphuric acid, phosphoric acid, (and traces of their bases, sulphur and phosphorus,) chlorine, potash, soda, lime, and magnesia, the latter generally in a state of union with carbonic acid, also a trace of iron. The analyses hitherto published refer, almost every one, only to the yolk of the new-laid hen's egg. Comparative analyses of the yolk of the ovum still contained in the ovary, and of the changes it undergoes, are unfortunately still entirely wanting.

[67] The fluids contained in the germinal vesicle coagulate, as has been already stated, in alcohol and acids, acetic acid among the number, which frequently fails to cause any coagulation in other albuminous fluids. When coagulated, the contents of the germinal vesicle form an irregular finely granular mass. A representation of the appearances may be found in my *Prodromus*, fig. xi. *b*, fig. xxviii.

[68] It were out of place to enter here into a disquisition, either upon what is called equivocal generation, or on the fissiparous and gemmiparous modes of procreation observed among the lowest classes of animals, our business being with sexual generation only. Gemmiparous generation, too, is very frequently distinctly referable to reproduction from ova.

[69] There does not exist a single undoubted case of hermaphroditism in man or in the other vertebrate animals, the presence of the germ-preparing organs of the male and female being of course regarded as necessary to constitute that state.

series, also, division of the sexes is the general rule, which occurs in insects, arachnidans, the majority of crustaceans, and many molluscs. Normal hermaphroditism, or that state in which spermatic fluid and ova are produced in one and the same individual, occurs, as it would seem, in conchylia; in many annellides, in the echinodermata, polypi, infusoria, &c., the two forms of sexual apparatus are found united, and lying at no great distance from one another. There appears to be no general rule applicable to these classes: closely allied genera frequently present themselves as sexually distinct in one case, as hermaphrodites in another. Among vegetables also, in the majority of instances, organs of two different kinds, which from analogy with the animal kingdom have been divided into male and female, appear to be necessary to reproduction [70].

All the cases of hermaphroditism hitherto observed have their grounds in defective formations of the sexual organs, or in permanence of some earlier stage of development, when the male and female organs still bear a strong resemblance to each other. Vide the critical remarks on the doctrine of hermaphroditism in Müller's *History of the Formation of the Genital Organs (Bildungsgeschichte der Genitalien,* 4to, Dusseld. 1830). The case observed by Rudolphi and described by him in the *Transactions of the Berlin Academy* for 1825, in which a testis and seminal conduits were found on one side, and an ovary and Fallopian tube on the other, is now rendered suspicious, like all the others, by the later researches of Müller. Cuvier speaks of hermaphroditic formations which he had observed in fishes *(Histoire Naturelle des Poissons,* i. p. 534); but here, too, a microscopical analysis, which was not made, would alone have been competent to decide the fact. Among several classes of the invertebrate series, insecta for instance, and among these particularly lepidoptera, abnormal hermaphroditic formation would appear actually to occur. On the subject of abnormal hermaphroditism in the animal kingdom, see the elaborate account by Burdach in his *Physiology,* vol. i. [See also the excellent article HERMAPHRODITISM, by Dr. Simpson, in Todd's *Cyclopædia,* vol. ii. which contains the details of a great number of cases, derived from various sources. Such close approximations to true hermaphroditism in the human subject have sometimes been made, that it would probably be rash to maintain the impossibility of such an anomaly ever occurring. R.W.]

[70] The subject of the reproductive organs of vegetables has been left, in what follows, almost entirely untouched; the contradictory character of the statements of the more recent inquiries, and the symptoms of an impending great revolution in the whole doctrine of the sexes of vegetables, made it impossible to approach this topic with any chance of profit. According to Schleiden's otherwise extremely interesting inquiries, it would appear that the pollen-capsule, instead of being the male, is much rather to be viewed as the female organ, being the part which furnishes the germ that is evolved into the embryo; Meyen and others, again, regard the fovilla of the pollen, as Brown, Brongniart, and others had done already, as the true semen, possessed of spermatic animalcules; finally, Valentin, whilst he agrees in the main with Schleiden's observations, rejects *in toto* the doctrine of the sexes of vegetables, and their analogy in this particular

§ 23. *Structure of the Sexual Organs in Man and Animals.*

The sexual organs of animals are naturally divided into GERM-PREPARING ORGANS—the testes and ovaria—which are essential, always present, and the analysis of which has just engaged us; TRANSPORTING ORGANS—vas deferens and oviduct ; and EMITTING ORGANS—penis and vagina, which at the same time serve as implements of sexual intercourse. In addition to this associated system of parts, there are added a variety of accessory organs, such as a reservoir of the matters elaborated in the germ-preparing apparatus, or, it may be, a secerning organ; in this category are placed the vesiculæ seminales, and the various and very numerous glands denominated prostate, Cowper's glands, follicles of the vagina, &c.; these are often entirely wanting ; in other cases they are highly developed [71].

§ 24. In the animal kingdom the testicles and ovaria are mostly formed after the same essential type, and in their structure bear all the character of organs of secretion : in many of the invertebrata—the acephalous bivalve molluscs, the crustacea, many insects, &c.—the testes and ovaria are either simple or ramified cœca, or pouches; in the hermaphroditic snails they form a common cluster; in those in which the sexes are separated, the testes and

with the members of the animal kingdom. Vide Schleiden in Wiegmann's *Archiv*, f. 1837, B. I. S. 289, and Müller's *Archiv*, f. 1838, S. 137, Valentin's *Repertorium*, f. 1838, S. 62. See also the observations already made under annotation 8 to § 5. In addition to the particulars just mentioned, and those referred to, it is necessary to state that Unger has lately published two valuable papers, accompanied by beautiful drawings, upon the spermatic animalcules of plants, in *Nova Acta Academiæ Cæsar. Leopold. Nat. Curios.* vol. xviii.(1837, pp. 687 & 786). In the first essay this writer describes very completely the seminal animalcules of sphagnum. In the second he gives delineations of those of polytrichum (which agree very much with those of sphagnum), and of marchantia. He has also found very similar bodies in other mosses (funaria and bryusca), and, besides marchantia, in grimaldia hemispherica. To examine these bodies it is necessary to seize the precise time at which the contents of the anthers attain their highest development. For polytrichum commune, one of the commonest mosses, the month of May is, according to Unger, the proper time for instituting researches.

[71] The brief summary contained in the immediately following paragraphs will suffice in this general physiological consideration of the morphology, inasmuch as, with the exception of testes and ovaria, the other sexual organs are really of little importance, and the insight into the nature of the reproductive process is not facilitated by any more particular consideration of them.

ovaria exhibit precisely the same structure, and are only to be distinguished by the nature of their contents. In fishes both organs present themselves as great sacs, or flattened and elongated masses; in the stroma of the testis we usually meet with long convoluted tubes, more rarely small round vesicles; in the ovaria, on the other hand, we have shut capsules; the resemblance decreases when we come to the mammalia and man; greatly elongated and extremely slender canals, pressed and wound together like a skein of thread, and packed up within a common membranous envelope or capsule, is the characteristic structure of the testis; round, shut, racemiform clustered, but not communicating cells, is that which is proper to the ovary. Both testes and ovaries in all the higher animals lie under the kidneys; in many mammalia, too, the testes as well as the ovaries are contained in the abdomen, or they return into its cavity during the season of heat, so that the position externally of these organs is lost as a permanent character. The convoluted canals of the testis secrete the semen, the close ovarian cells the ova[72].

§ 25. In the higher vertebrate animals, and in many of the invertebrate series also, the seminal canals or vessels open into a wider membranous canal—the vas deferens, which conducts the spermatic fluid outwards; the oviduct, however, the analogue of the vas deferens in the male, is not in uninterrupted connection with the ovary; still it is so very generally among the invertebrata, and there is even a tendency to continuity in many mammalia;—in the greater number of the carnivora, for example, a membrane proceeds from the edge of the opening of the Fallopian tube, which surrounds the ovary in the manner of a bag or capsule, more or less completely. In many animals, as in fishes, the tubuli seminiferi and oviducts are extremely short, and are in fact no more than narrower processes or prolongations of the sacculated testis or ovary; in many species even these are wanting, and the semen and ova are shed directly into the abdomen, whence they are extruded through peculiar clefts in its walls.

[72] For an account of the various forms of the male spermatic organs, see particularly Müller's able work, *De Glandularum secernentium Structura*, fol. Lips. 1830 (in English by S. Solly, 8vo. Lond. 1839). For details of the analogy in structure between the ovaria and the testes in the animal series, I beg to refer to my *Elements of Comparative Anatomy*, chap. vii. p. 290 et seq. (in German). Tables i. and ii. in Burdach's *Physiology*, vol. i. give a good view, or rather scheme, of the principal forms of testicle and ovarium observed in the animal kingdom.

Proper external organs of generation occur but in individual classes and orders of animals; in the Mammalia they are general; so are they also in the scaly Amphibia and in Insects; they are much less general in other classes, in Birds for example, the smooth-skinned Amphibia, Fishes, &c.; in the Snails they are met with commonly enough[73].

§ 26. The general consideration of the morphology of the human organs of generation, shows us certain relations which serve to elucidate many physiological phenomena. What we learn admits of application, and furnishes us with analogies in reference to the same system through the whole of the series embraced by the animal kingdom. The TESTICLE is composed of TUBULI SEMINIFERI, canals of great tenuity, which are every where copiously surrounded by blood-vessels. The tubuli anastomose with one another in loops. When unravelled from the tangled skein which they form naturally, they constitute a canal of the delicacy and diameter of a sewing-thread of more than a thousand feet in length; the amount of secreting surface is consequently very considerable. The tubuli unite into a variable number of excretory ducts, which pass into a thicker convoluted and looped tube, the EPIDIDYMIS, which in its turn terminates in a simple contorted canal, the VAS DEFERENS, which at its terminal extremity is provided with a diverticular appendage, the VESICULA SEMINALIS. This last appendage seems to serve partly as a reservoir for the spermatic fluid, partly as an organ of secretion; it is not found in many mammalia. The PROSTATE and COWPER'S GLANDS are secernent organs, the clear viscid secretion of which consists of a transparent liquid intermixed with flocculi and granules, which are mostly either normal or altered epithelial cells. The PENIS is a highly vascular organ, copiously supplied with nerves, which, in virtue of a peculiar and not yet perfectly understood mechanism of its blood-vessels, receives upon occasion such an afflux of blood, that it enlarges and stiffens, or undergoes erection, by which it is fitted to penetrate into the female vagina. The mucous or internal coat of the seminal vessels is furnished with a flattened cylindrical epithelium, which is continued into the vas deferens; the epithelial cells of the vesiculæ seminales, which are tessellated or united in

[73] See the description of the various forms pertaining to these organs, in my *Elements of Comparative Anatomy*, and Burdach's *Physiology*, vol. i. On the remarkable forms they present in fishes, see the older as well as the more recent writings particularly referred to by Rathke, in his contributions to Burdach, l. c.

the manner of a pavement, contain nuclei of considerable size, and, farther, a quantity of granular matter [74].

§ 27. The OVARIA of the human female have a very compact and solid stroma; each ovarium contains about fifteen fully-formed Graafian vesicles, in which the very small ovula (measuring from the 20th to the 30th of a line) are imbedded in the manner already described; the FALLOPIAN TUBES, as well as the uterus, contain muscular fibres, which have the histological (structural) character of those of the involuntary muscles; the VAGINA is narrow at its orifice in the virgin, and partially closed by the HYMEN, which, however, leaves an opening of about half an inch in width superiorly; the CLITORIS is small; the mucous follicles situated between the labia and in the vagina secrete a fluid of a peculiar greasy odour [75]. The MUCOUS MEMBRANE between the labia pudendi, and covering the hymen and vagina to the middle of the cervix uteri, is covered with a tessellate epithelium; from the point indicated this is replaced by a cylindrate epithelium, which

[74] For further details concerning the male organs of generation, see the elementary anatomical works of Hildebrandt, by Weber, and of Krause. The best description and representation of the testis we possess, are those by Lauth, *Mém. sur le Testicule Humain, in Mém. de la Société d'Hist. Nat. de Strasbourg*, tom. i. liv. ii. 1833. He estimates the entire length of the seminal canals at 1750 feet; Krause thought that the mean length might be fairly stated at 1015 feet; the diameter of the seminal vessels varies from the twelfth to the sixteenth of a line, a statement with which my admeasurements coincide. Vide Krause in Müller's *Archiv* für 1837, S. 24. The vesiculæ seminales are wholly wanting in many animals, in the dog for example. Others of the accessory organs of generation, however, are very much developed in certain mammalia, for instance in the hedgehog, and many other insect-feeders and gnawers. Vide my *Elements of Comparative Anatomy*, § 256. With regard to the arteriæ helicinæ, the extreme divisions of which, associated in bundles like skeins of thread, have been held the efficient causes of erection, see Müller in his *Archiv* für 1835, S. 202, the dissentient observations of Valentin, and Müller's reply in the same periodical for 1838, pages 128 and 224. It seems very difficult to arrive at any thing like certainty in regard to the structure or disposition of the blood-vessels of the corpora cavernosa; I have not myself been able to come to any satisfactory conclusions; at present I look on the arteriæ helicinæ as retia mirabilia. See further under § 37. On the epithelial indusium of the male urogenital mucous membrane, see Henle's excellent Memoir in Müller's *Archiv für* 1838, § 112.

[75] Perhaps this peculiar-smelling secretion may be poured out by that pair of glands, the representatives of the glands of Cowper in man, which have been lately described by Mr. Taylor. These glands are considerably larger than in man, situated at the root of the corpora cavernosa clitoridis, and open into the vagina by excretory ducts of an inch in length. Vide Taylor, in *Dublin Journal*, 1838, copied into Schmidt's *Jahrb. f. Medizin*, Bd. XX. S. 5.

is continued through the tubes to the edges of their fimbriated extremities, where it passes into the tessellate epithelium of the peritoneum; the epithelial cylinders have similar nuclei, and carry cilia the $\frac{1}{300}$th of a line in length. In the mammalia, where the structures are all essentially the same as in man, the cilia may be seen many hours after death in rapid motion. After every menstrual period, certainly after every conception, the ciliate epithelium is thrown off and reproduced; the epithelium of the vagina is always in a state of copious desquamation. The ciliate epithelium is wanting before puberty, and after the period of childbearing is past; in animals it only makes its appearance when they have attained the age at which they can engender[76].

§ 28. *Comparison of the male and female Organs of Generation in the earliest periods of development.*

In man, and indeed in animals generally, the sexual organs are those that make their appearance the latest of any; they are even later than the kidneys and suprarenal capsules. In embryos of a month old there is still no trace of organs of generation to be discovered, although at this period the brain, spinal cord, heart, lungs, intestinal canal, liver, &c. &c. are plainly enough evolved. A pair of organs, peculiar to the fœtus in the very earliest stages of its existence, the corpora Wolffiana (§ 61, fig. LXXXV. *f*), occupy a conspicuous place in the abdomen, being situated one on either side of the vertebral column. It is in the course of the sixth week, when the corpora Wolffiana have already begun to decline in size, that the germ-preparing organs first show themselves as a couple of minute points on the upper and inner edge of these bodies; to the outside and upon or within the excretory ducts of the Wolffian bodies, a couple of threads next make their appearance, which gradually increase in size, become hollow, and finally change into the vasa deferentia or Fallopian tubes; they open downwards along with the ureters into the cloaca or *sinus urogenitalis* of Mül-

[76] See the account of the epithelium of the genital system of the female in Henle, loc. cit. Henle states that even on the outer surface of the fimbriæ of the tubes, there are still ciliate epithelial cylinders to be detected. I have always supposed, at least in animals, that I could observe the sudden cessation of these at the peritoneal edge. To observe the play of the cilia, and study the structure of the epithelium, let a full-grown rabbit be taken, which is not pregnant, and has not too recently had young. On the subject of the ciliary motions, see the third Book of this work.

ler, which receives at the same time the termination of the intestine and the excretory duct of the Wolffian bodies, and in the first instance forms a blind sac; for the anus only appears at a later period. By degrees the intestine recedes, as it were, from the sinus urogenitalis, and thus the perinæum is formed; the anterior part of the sinus again is transformed into the bladder, and its middle part in the female into the uterus. Simultaneously with the development of the internal organs of generation, namely, during the sixth week, a small prominence makes its appearance immediately in front of the depression that indicates the anus; this is the penis or clitoris, which soon shifts its place, comes much forwards, and exhibits underneath a canalicular depression; by the end of the second month, two folds have sprouted up on either side of this organ, which by and by show themselves as the scrotum or labia majora, according to the sex. In the second month it is still impossible to distinguish between the sexes of embryos (figs. XCI. XCII. XCIII. and CI.); it is only in the middle of the third month that recognizable diversities in point of form announce diversity of sex; the period at which differences in point of structure proclaim the same thing is still considerably later; at the tenth week the two sexes still bear the strongest resemblance to one another (fig. XCIX. and C.). The testes become rounder, the ovaria longer; both, especially the ovaria, retreat backwards towards the sinus urogenitalis, which, when the sex is feminine. now begins to be transformed into the uterus, and to be drawn out into cornua, from which the round ligaments arise, and run towards the inguinal canal; the oviducts and seminal ducts (Fallopian tubes and vasa deferentia) become strikingly different, and the latter are connected with the testes by the medium of the epididymis. In the fourth month the canalicular cleft of the penis is closed and becomes the urethra; on the clitoris, on the contrary, the edges of the cleft rise more and more, and become the labia minora. At the beginning of the fifth month the penis and clitoris are still very much of a size; in the course of this month, the lateral folds coalesce in the middle line, by which the raphé and the scrotum are formed in the male, whilst in the female embryo the labia majora are produced from these lateral folds, and cover and conceal the clitoris more and more. The vesiculæ seminales first appear in the fifth month, and arise as offsets from the extremities of the vasa deferentia. The testes continue within the cavity of the abdomen till the end of the seventh month; they then descend

through the inguinal eanals, and in the ninth month attain the bottom of the serotum (the deseent of the testicle)[77].

CHAPTER III.

PHŒNOMENOLOGY OF THE GENERATIVE ACT.

§ 29. *Encounter of the Generative Elements.*

In entering on the eonsideration of the phenomena whieh eompose the generative aet, it is well to meet at the outset the prineipal questions whieh must neeessarily be answered before any eloser insight into the nature of the proeess ean be obtained. The most weighty question of all this is—Must the generative elements whieh are severally prepared in the male and female sexual organs eome into actual eontact to produee their peeuliar effeets? and, the answer being in the affirmative, how and in what way is this eontaet aeeomplished? The deeision of the point involved in this question is linked with extraordinary diffieulties in man and the higher animals; so that we must turn to the remoter eireles of organic nature for faets and observations to guide us in seeurity along this obseure provinee of physiology. In the vegetable kingdom the researehes of very recent times in regard to the sexes of plants have demonstrated the oeeurrenee of an intimate material

[77] A very important paper by Valentin on the development of the follicle in the ovary of mammalia, has lately appeared (Müller's *Archiv* f. 1838. Heft. V. S. 526). The earliest histological metamorphoses are there traced with greater care than had hitherto been done. The testes and ovaries are evolved after the type of glands in general: lappets appear in a blastema, which change into canals. The difference between the two organs occurs subsequently; in the testis the seminal tubes are formed, and they become united to the vas deferens; in the ovary blind tubuli arise stellated from a solid mass in the centre; in these tubuli the follicles are first formed, after which the tubuli disappear. The interior of the tubuli, as well as that of the seminal canals, is beset with epithelial globules. In spite of everything that has been done, however, the evolution of the germ-preparing organs has not yet been followed with all the attention that seems desirable. The observations of Valentin were principally made upon young embryos of the sheep.

The subjects treated of in this paragraph will be found again touched upon in our history of Development, particularly in § 74. Vide Müller's history of the development of the genital organs (*Bildungsgeschichte der Genitalien*, Düsseld. 1830), and the brief but very clear account of the subject in Lauth's *Manuel d'Anatomie*, t. ii. See also the figures under § 73 and § 74. XCIX.—CIV.

contact between the pollen granule with its fovilla, and the nucleus of the ovum; as soon as this, and only when this has been accomplished, is an embryo evolved [78]. Among the lower orders of vertebrate animals, as in the frog and toad, we see the male seated on the back of the female, and shedding the semen over the ova at the moment they leave, or immediately after they have left the cloaca; the union of the sexes here continues for a shorter or longer time, —for hours or weeks, but always as long as ova are extruded [79]. In osseous fishes, among which no kind of embrace takes place, careful observers have seen that the females are followed by the males, that they turn their bellies to each other, rub the anal orifices together, and that the semen of the milt-fish is shed during the time when the roe-fish is depositing her spawn [80]. Among invertebrate animals, snails and insects are frequently observed in intimate conjunction for hours together; the coitus ended, or the creatures separated, the spermatic fluid will be found in appreciable quantity collected in particular sacculi, or receptacles of the female, the outlets from which are so placed that the ova, as they are extruded

[78] In vegetables, the peculiar material incident by which the pollen capsules are conveyed, often by a very lengthened route through the cellular tissue of the style to the receptacle, and through the opening or micropyle of the embryonal sac to its nucleus, has been placed beyond the reach of question by the observations of Brown, Brongniart, Amici, Corda, Schleiden, Wydler, Valentin, and others. It is only in regard to the organ or element that is actually developed into the embryo, that unanimity of opinion has not yet been obtained. After the occurrence mentioned, however, and only then, is it that the embryo begins to be evolved.

[79] In regard to the frog, the excellent researches of Roesel, in his *Historia Ranarum nostratium*, fol. Nürnb. 1758, may satisfy whoever has no leisure or inclination to undertake inquiries for himself. In the green frog (Rana esculenta) the male must often continue his embraces of the female for thirty or forty days, the exclusion of the ova from the cloaca extending over this interval of time. In the brown frog (braunen grasfrosch), the ova of which are extruded in a single mass in the course of a quarter of an hour, the connection is much shorter; as soon as the ova are fairly expelled, the male discharges his fecundating fluid over them, and immediately afterwards quits the female. In the tree frog the pairing lasts about three days and nights before the spawn is shed; the period over which the shedding extends is very various, from two to twenty-four hours; if it proceeds too slowly, the male is apt to forsake the female before it is completed, in which case the last laid ova prove unfruitful. Precisely similar circumstances are observed in regard to the bufonidæ and several other animals.

[80] On the pairing of fishes see the observations of Grant and of Argillander, as they are reported by Von Baer, but augmented by several peculiar to himself, in his *Researches on the Development of Fishes*, (Untersuchungen über die Entwickelungsgeschichte der Fische) Lips. 1835.

in succession, must necessarily glide past them [81]. These examples, chosen from very different groups of the organic kingdom, might be readily added to; they all tend to prove that in the generative act, under whatever variety of circumstances this takes place, whether with or without coitus, the semen and the ova are brought into mutual contaet.

§ 30. It is infinitely more difficult to speak definitively as to what passes in the interior of the female organs of generation in the higher vertebrate animals. The older accounts of semen having been found in the uterus in the dead bodies of women, are unsatisfaetory, inasmuch as the only certain means of distinguishing semen, viz. microscopic analysis, was not then employed. On the other hand, however, the presence of spermatozoa in the interior of the female sexual organs, after the access of the male, may be demonstrated by direct experiment in the case of birds and mammalia. Some of the older observers had already detected living spermatozoa, even several days after coitus, in the vagina and uterus, as high as the commencement of the Fallopian tubes of the bitch and rabbit [82]. More recent inquirers have amply authenticated these discoveries [83]; and there can now be no question but

[81] Audouin has called the bag or bladder in the female insect which receives the semen, *poche copulatrice.* If butterflies, chaffers, &c. be taken *in coitu,* this pouch will always be found full of semen, containing an abundance of active spermatozoa; see my *Contributions to the History of Generation,* (Beiträge, &c.) p. 560. A very complete anatomical and physiological paper of Siebold, assigns the receptaculum seminis as a very general structure among insects. Müller's *Archiv,* 1837, S. 392. See also Newport's article INSECTA, in the *Cyclopædia of Anatomy and Physiology,* vol. ii. p. 993.

[82] In Leeuwenhoeck's unrivalled works there are many very remarkable observations on this subject, observations which have not been duly appreciated in later times. He caused bitches to be served several times with the dog, the last coitus being made to take place one or two days after the first, and he always found spermatozoa in great numbers, not only through the whole body of the uterus, but in both of its cornua, to the commencement of the Fallopian tubes. Vide *Opera Omnia,* i. p. 149. Observations of the same kind were made on rabbits, *ibid.* p. 66.

[83] The researches of Prevost and Dumas, which have been confirmed by myself and others, are very conclusive. The physiologists named, on opening the bodies of bitches and female rabbits twenty-four hours after coitus, found spermatozoa in numbers, and moving with vivacity in the horns of the uterus; there were none in the vagina; on many occasions they perceived a thin transparent serous fluid in the capsule around the ovary, but no spermatozoa. In bitches, so long as three and four days after coitus, the Fallopian tubes were still found to contain spermatozoa in small numbers; the cornua of the uterus, however, contained many, which were extremely lively; but in the fluid from the precincts of the

that the facts as particularly stated in regard to the dog and rabbit, are quite general. Spermatozoa may be found in the recently dead bodies of almost all animals that are frequently in heat, and produce several litters in the course of the year. In the female rat and mouse, for instance, it is very common to find spermatozoa, so easily distinguished in these creatures by their highly characteristic forms, lying in masses within the cornua of the uterus, and even in contact with the ova which have but just entered them[84]. In birds, also, the same circumstances are frequently to be observed. In a general way, indeed, success has not attended the attempts that have been made to trace the spermatozoa to the immediate vicinity of the ovaria; still, in several instances, recent observers have actually discovered spermatozoa within the capsular prolongations of the Fallopian tubes that inclose the ovaria[85].

ovaria there were never any to be discovered. Even on the sixth and seventh day spermatozoa could be distinguished in the cornua, but their number was now much diminished; in the tubes none were to be found. *Annales des Sciences Nat.* tom. iii p. 119—122.

[84] Vide my observations on the rat, in Froriep's *Neue Notizen*, Bd. iii. No. 51. July, 1837. Between ova which had but just become attached, I found masses of spermatozoa of the characteristic forms already described.

[85] Dr. Bischoff, of Heidelberg, lately communicated the following observation to me by letter:—" I have now," says he, "completely satisfied myself that the spermatic fluid reaches the ovary. After having repeatedly found spermatozoa in the vagina, and particularly, though no longer alive, in the Fallopian tubes, in bitches, some time after the intercourse of the male, I was at length so fortunate as to discover the fact I have announced, in a bitch which had been in my possession previously to falling in season for the first time, and which I knew for certain to have been lined first on Thursday, the 21st of June, 1838, at seven o'clock in the evening, and again on Friday, at two o'clock in the afternoon. This bitch was examined half an hour after the last encounter; I found spermatozoa alive and active in the vagina, in the uterus, through the whole length of the tubes and between their fimbriæ, and finally in the sac or capsule which the peritoneum forms around the ovary, and even upon this organ itself. There could be no doubt of the fact as I state it. I have preserved the other cornu of the uterus in spirit; perhaps spermatozoa may yet be recognizable in it." I myself made an observation on the 3rd of December, 1838, which confirms this of Bischoff in almost every particular, which in fact differs from his in little, save as regards the time at which it was made, but may not perhaps be considered the less interesting on that account. The subject of my observation was a bitch which had been kept at the anatomical theatre of this place for the last four years, and which had already littered eight times (the last time in the spring of the year). This bitch had been observed to be in heat for eight days; she was served in my presence at one o'clock, p. m. and immediately after the coitus, which lasted some twelve minutes, was at an end, she was shut up. After the lapse of exactly forty-eight hours, the animal was destroyed and examined. The vagina was found somewhat bloody, but otherwise dry; indi-

§ 31. That immediate contact of the spermatic fluid with the ova is necessary to fertilize these is farther shown by the experiments on artificial impregnation which were performed by the inquirers of the last century with every precaution and great diligence. In regard to vegetables, it has been long since proved that artificial fertilization was readily accomplished in diclinial (monœcious and diœcious) plants by transferring the pollen of the

vidual spermatozoa were found lying everywhere between the large epithelial scales; these spermatozoa were all dead. In the uterus the number of spermatozoa was greater, and here they were all alive. The number and activity of the spermatozoa increased conspicuously in the cornua of the uterus and in the Fallopian tubes; but it was at the abdominal end of the tubes that the animalcules presented themselves in greatest abundance; here they completely filled every depression of the mucous membrane in aggregated masses; their motility continued for three hours in albumen on the stage of the microscope. In the capsule or pouch around the ovary I did not discover any spermatozoa, but I saw many full of activity and vigour among the fimbriæ, on the right side and close to the ovary, in which there were three Graafian vesicles very prominent, one of them having even already given way. On the left side there were no spermatozoa found betwixt the fimbriæ, but many at the abdominal opening of the tube. In the ovary of this side there were two Graafian vesicles ready to burst. The cilia on the mucous membrane of the fimbriæ were in lively action, but what seems remarkable is this,—that though I could readily trace the cylindrate epithelium through the whole uterus and tubes, yet it was uniformly without cilia. In the vagina there was nothing but tessellate epithelium. The slightly milky fluid (milky from the admixture of oily particles), which was believed by older observers to be semen, filled the capsules about the ovaries, especially the one on the right side, to the amount of several drops; it, however, contained no spermatozoa.

[Dr. Martin Barry has also observed spermatozoa on the ovary. His words are: "in seventeen out of nineteen instances in the rabbit, though the parts were generally examined while still warm, I was unable to discover spermatozoa in the fluid collected from the surface of the ovary. In the other two instances, however, spermatozoa, or at least animalcules exactly like those I had been accustomed to meet with in the uterus and vagina, were really found on the ovary. I should rather say, that on one of those occasions spermatozoa were seen, while on the other it was a single spermatozoon that was observed. Some of the former were alive and active, though not in locomotion; others were dead. In that case, twenty-four hours *post coitum*, there was neither enlargement of the Graafian vesicles, nor a high degree of vascularity in any of the parts. In the other instance the single spermatozoon found was dead, and the ova had escaped. * * * * Whether the seminal fluid penetrates into the interior of the ovary, I am unable to determine; but certainly the changes above described, as taking place *post coitum*, in the condition of the ovum, while still in the ovary, are too remarkable not to favour the supposition that it does." *Researches in Embryology*, second series, *Phil. Trans.* for 1839, p. 315. It is worth noting that the observation of Bischoff, recorded in the preceding part of this annotation, was made on the 22nd of June, 1838; those of Dr. Barry on the 5th and 6th of September, and that of Professor Wagner on the 3rd of December, in the same year. R. B. T.]

one flower to the stigma of the other. The ova of frogs, toads, newts, and different fishes, are in like manner readily fertilized by having a little of the spermatic fluid of their several males passed over them; and even among mammalia impregnation seems actually to have been effected by the injection of spermatic fluid by artificial means into the vagina[86].

§ 32. Experiments of an opposite character, or in which the male sperma is prevented from reaching the ova, prove that material contact is indispensable to fecundation: the ova of the frog and of fishes, unless brought into contact with the sperma of their several males, remain unfruitful[87]. Among birds, the general rule is that no eggs are laid unless fecundation by the male has taken place; still it often happens that the common fowl lays eggs without having been trodden by the cock; these eggs, however, are

[86] The experiments of Koelreuter on vegetables ("A short Account of certain Experiments in regard to the Sexes of Plants, Lips. 1761," and "three supplements, ib. 1763—66." in German), deserve to be mentioned; as also those of Conrad Sprengel ("The Secrets of Nature discovered in the Structure and Fertilization of Flowers, Berl. 1793," in German). The "Biologie" of Treviranus contains a complete summary of these matters, as also of the subjects handled in several of the succeeding paragraphs of the text. On the artificial fertilization of the ova of frogs and toads, see the classical work of Spallanzani—*Esperienze, &c.* There, too, Spallanzani relates the remarkable case, in which, by means of a syringe, warmed to 30° R. he injected the spermatic fluid of a dog which had had an emission, into the vagina and uterus of a bitch in season, the animal having been as many as thirteen days confined previously to coming into heat, and the experiment being performed on the twentieth day, when the œstrum was at its height. Two days after the injection the animal ceased to be in heat; after a lapse of twenty days the abdomen began to enlarge, and on the sixty-second day she produced a litter of three puppies, two males and one female, which were very lively, and in their general shape and colour very much resembled not only the mother, but the dog from whom the spermatic fluid had been obtained for the experiment. The bitch was of the poodle breed, and had already had a litter. Professor Rossi, of Pisa, is said to have repeated this experiment with success: *Opuscoli scelti di Milano*, t. v. p. 96: in the translation of Spallanzani into German, p. 343. Rusconi has fertilized the ova of the tench (cyprinus tinca) artificially: he compressed the abdomen of the female at the spawning season, and received the ova as they fell from the anus into a vessel of water; he pressed the abdomen of a male fish in the same manner, and caught a few drops of the seminal fluid in the same vessel; the fluid diffused itself as a slight cloud in the water, and actually impregnated the ova. Müller's *Archiv* für 1836. S. 278.

[87] Here, too, the experiments of Spallanzani are highly important. He inclosed the lower part of the body of a male frog in a pouch of oil-silk; the animal copulated with the female as usual, plenty of spawn was laid, but not a single ovum came to anything. On examing the oil-silk covering, he found the spermatic fluid clinging in drops to its interior.

unfecundated and not proper for incubation; they spoil rapidly instead of producing a chick when set under the parent[88].

§ 33. We know that among many of the lower Vertebrata the ova of the female are extruded before fecundation has taken place, and that therefore the separation of the ova from the place of their formation is not in direct connexion with their fecundation. The extrusion of the ova in these cases is to be viewed rather as a consequence of the excitement arising from sexual intercourse. Among mammalia and in man, on the contrary, the rule would seem to be that no ova are detached from the Graafian vesicles unless fecundation has taken place. For this reason, that opinion appears improbable according to which the product of the ovary, even in those cases in which fecundation is accomplished internally, is cast loose to meet the sperma[89]. The grounds for believing that

[88] Baer, in his "History of Development" (*Entwickelungsgeschichte, &c.*), vol. ii. p. 24, says:—"The greater number of birds also lay eggs only after they are impregnated. In very productive birds, however, ova often free themselves spontaneously from the ovary, and it is well known that hens, which are amongst the most prolific of all birds, lay eggs even when they have had no intercourse whatever with the cock; these hens, however, begin to lay later than those that have been duly visited by the male bird. The same circumstance happens not very uncommonly among others of our domestic poultry. And individual instances of its occurrence are reported among birds in general."

[89] [The determination of the periods at which, and the circumstances under which ova are or may be cast loose from the ovary among animals, and especially in the human female, is a point of great interest, and may upon occasion become one of much importance. It is familiarly known and admitted that among the lower animals Graafian vesicles very generally burst, and of course shed their contents, towards the end of the period of heat, whether they have had connexion with the male or not. So long ago as the year 1672 the celebrated Kerkring (*Phil. Trans.* 1672.) maintained that ova were occasionally, at least, discharged from the ovary of the human female during the menstrual period. Subsequently it was several times observed that the ovaries of females who had died during the menstrual period presented appearances which could only be referred to the bursting of one of the Graafian vesicles. A remarkable case of the kind is recorded by Sir E. Home (*Philos. Trans.* 1817). Dr. Power (*An Essay on the periodical discharge, &c.* 8vo. Lond. 1832) seems to have been the first who ventured an opinion to the effect that the phenomena of menstruation were connected with the escape of an ovum from the ovary, but as this was strengthened by no particular facts, it can be viewed only as an ingenious conjecture. It was Dr. R. Lee (Art. Ovaria, in *Cyclop. of Pract. Med.* Lond. 1834) who from positive data—from repeated examinations of the bodies of women who had died while menstruating, and a comparison of the results of experience in reference to disease, and absence, and loss of the ovaria, first maintained that "all the phenomena of menstruation depend upon or are connected with some peculiar change in the Graafian vesicles, in consequence of which an opening is formed in their

the fecundation of the ovum takes place in the ovary are as follows: 1st. The fact that the semen penetrates to the ovary. 2d. The circumstance that the ova of birds, and also of mammalia, advance to maturity partially and in succession, and are also detached from the ovaria in the same manner, and that the fecundated ova in different families of the mammalia first make their appearance in the uterus after the lapse of a certain interval of time, more or less considerable, from the last visit of the male, an interval which is often so considerable as to render it improbable that the semen continues accumulated in the uterus during its course[90]. 3d. The occurrence of cases of extra-uterine conception, which are by no means unfrequent either in the human subject or among animals, speak loudly for impregnation of the ova in the ovary; in these cases the embryo commences and continues its evolution in the

peritoneal and proper coats." "Menstruation," he goes on to say, "probably does not take place during infancy, because the ovaria are not then developed; it is absent during pregnancy and lactation, because at these periods they are in a quiescent state; and after the age of forty-six the catamenia cease, because the parenchymatous structure of the ovaria has partially disappeared and the Graafian vesicles have degenerated." M. Gendrin (*Traité Philos. de Méd. Prat.* t. ii. 8vo. Paris 1839) has adduced several new and interesting facts which amply confirm these conclusions of Dr. Lee, without noticing them however; and he infers that "the menstrual hemorrhage is but the periodical expression of a function which begins with puberty and ends with the critical age, and that this function consists in the production and development of the ovarian vesicles;—it brings a vesicle, and therefore an ovum, periodically to maturity on the surface of the ovary, to be thence either expelled or destroyed by the rupture and the inflammation of the vesicle" (l. c. p. 29). Vide further on the evidences and effects of this periodical process, in the annotations under § 68. R. W.] Burdach enters fully into the reasons for and against this view, *Physiologie*, vol. i. § 292). He concludes that in absolute internal impregnation, as well as in that which is external, the product of the ovarium and the spermatic fluid come into immediate contact.

[90] In rabbits, ova are usually found in the cornua of the uterus on the third day after effective coitus; in the dog, and, it would appear, in the human subject also, the ova do not enter the uterus before the eighth day. Roe-deer are very remarkable in regard to the time at which the ova enter the uterus. Among these animals the rutting season, and with it sexual intercourse, occur towards the end of August and beginning of September; at this time Pockels found the uterus turgescent, full of blood, and the mucous membrane spongy; but he saw no change in the ovaria; immediately after this the turgescence of the uterus declines, and it is only at the end of December that the effects of the sexual intercourse begin to show themselves; there is now a fresh turgescence of the uterus, a grasping of the ovary by the extremity of the Fallopian tube, and enlargement of a Graafian vesicle; at the beginning of January the embryo, of extremely minute size, is discovered for the first time in the horn of the uterus. See Dr. Pockels' very interesting paper in Müller's *Archiv* für 1836. S. 193.

ovary or in the cavity of the abdomen, as the case may be, and often attains maturity with a perfectly normal condition of all its members. 4th. Direct experiments, which, though they are inadequate to decide, yet powerfully support this view: if the oviducts, or Fallopian tubes, be tied or divided in animals immediately after sexual intercourse, and before, according to the data supplied by observation, the spermatic fluid could have penetrated to the ovary, no fecundation, no development of ova follows; whereas the ligature or division of the same parts, if not performed for two or three days after coitus, has no influence in preventing the evolution of the embryo[91].

§ 34. It is not absolutely necessary in man and the mammalia that the male organs of generation should penetrate completely into the corresponding organs of the female, in order that impregnation may follow the sexual act; this indeed is facilitated by such

[91] The experiments of Haighton on rabbits are highly important: the division of one oviduct (Fallopian tube) performed from one hour and a half to four hours after coitus, prevented the bursting of the vesicles on both sides; if the operation was performed forty-eight hours after coitus, fewer vesicles burst on the injured side, and no embryo was developed; on the uninjured side however perfect fecundation followed. The division effected sixty hours after coitus had no influence in impeding the development of the embryos on either side. When coitus took place after the division and closure of one of the tubes, Haighton found a vesicle of the corresponding ovary ruptured, but no embryo was produced; on the uninjured side, on the contrary, impregnation and development followed as usual. Vide *Phil. Trans.* for the year 1797. These inquiries are often quoted amiss, and spoken of as if they favoured the opinion that the stimulus of the sexual act was regularly followed by the rupture of a Graafian vesicle. Vide § 41. [See also Dr. Blundell's experiments confirmatory of these views in *Medico-Chirurg. Transactions,* vol. X. The experiments of Haighton have been variously interpreted according to the views of individuals and to the appearances in the ovary which were held significant of impregnation. Dr. Haighton himself regarded his experiments as leading to conclusions other than those in the text; he says expressly that they "overturned any argument which has been adduced to support the hypothesis that the effusion of semen on the ovaries is essential to impregnation," which he ascribes entirely to *sympathy;* "the semen stimulates the vagina, os uteri, cavity of the uterus, or all of them; by sympathy the ovarian vesicles enlarge, project, and burst," &c.: here he assumes the presence of corpora lutea in the ovaries as indubitable evidences of impregnation having occurred; he sets out in his inquiries, indeed, with the axiom that "no corpora lutea ever exist in virgin animals," and therefore concludes that wherever they occur there impregnation has preceded. But having constantly observed that though corpora lutea presented themselves in the ovary of that side the Fallopian tube of which had been divided, no embryo was ever found there, whilst on the opposite side where the Fallopian tube was entire both corpora lutea and embryos were discovered in like numbers, he asks, "if

a penetration, but it is enough that the male sperma be simply so thrown or introduced into the female organs, as that it may by possibility reach the os uteri; this may happen without destruction of the hymen, the injection taking place through its opening; the continued advance of the spermatic fluid after this,—its passage through the uterus and along the Fallopian tubes,—is secured partly by the ciliary motions which begin in the cervix uteri, partly by the contractions of the tubes, and partly by the motility of the spermatozoa;—which of these various means proves the most efficient in accomplishing the purpose in question, cannot at present be determined. There are decisive cases as regards man, in which fruitful intercourse has taken place without actual intromission [92]; men with malformations of the intromitting organ,—with hypospadias and epispadias of the worst kinds; men who have had the penis partially amputated, in whom but a very imperfect coitus could take place, have all proved their capacity to engender [93]. Those cases, on the contrary, are highly improbable, and generally not well or truly reported, in which impregnation is said to have taken place along with entire closure of the vagina, with a completely imperforate hymen, or in which the external surface of the abdomen, or the clothes only, were wetted by the seminal fluid in the course of an incomplete or forcibly attempted coitus [94].

§ 35. We have now to inquire into the more immediate conditions necessary to fecundation as regards the quantitative and

the application of semen to the vagina or uterus be sufficient to stimulate the ovaries to perform their first procreative functions without enabling them to achieve any thing more? and does it require the active energies of the seminal fluid operating by direct contact on the surface of the ovaries to produce the full measure of their effects?" The answer we should give to these queries would be in the spirit of the text: the ovaries in a fertile female animal do already and of themselves perform their first procreative functions, i. e. they prepare ova and perchance even cast these loose during the season of heat or menstruation; and farther, the active energies of the seminal fluid, operating by direct contact with the surface of the ovaries or the ova, are required to have this first procreative function made effective, to have it followed by the development of an embryo. R. W.]

[92] Cases of the kind occur in many of the later as well as earlier writers (vide Burdach, *Physiologie*, i. 528). Very recent cases are related by Heim, Ribke, Casper, and myself. Vide Casper's *Wochenschrift*, 1835, Nos. 1, 3, and 29; Henke's *Zeitschrift*, 25tes *Ergänzungsheft*, S. 1.

[93] Burdach quotes the cases in which malformations of parents are transmitted as affording security against any possible mistake.

[94] In these cases of coalescence of the vagina and the like, there was undoubtedly always an opening, however small. Against the idea that impregnation can follow simple wetting of the linen, &c. vide Henke in his *Zeitschrift* f. 1837, S. 1, and the whole of my previous and further remarks.

qualitative relations of the sperma to the ovum, and the reeiproeal influenee of these upon one another. The ehief eonditions are :, 1. That the ovum possess a eertain maturity of its elements, espeeially, as it would seem, of its vitellus or yolk; it is not, however, always neeessary that the yolk be eompletely developed in order that feeundation be effeeted. Among birds, for instanee, several ova very unequally advaneed, and that go on ripening gradually, and attain maturity in sueeession, are often feeundated at onee; a great number, however, still remain unimpregnated in these eases, and do not advanee. Among amphibia and fishes ripe ova only, and these even exeluded from the ovaria, ean be feeundated artifieially; in man and the mammalia the ovarian vesieles that burst are the largest, and therefore it may be presumed the ripest. 2. The sperma must be reeent. The feeundating power of the male seeretion is not always lost suddenly, or even very speedily; and the period at whieh it eeases is different in different animals :—among frogs and fishes the sperma will still feeundate that was taken from the bodies of animals killed hours before. The power is probably in relation with and dependent on the vitality of the spermatozoa; these, as we have seen, are found alive and active after several days in the natural passages, espeeially amidst the slime of the uterus and tubes; they die very mueh sooner out of the body. 3. The quantitative relation of the sperma seems to have but little influenee on its feeundating power; a very small quantity suffiees among the lower elasses of animals to fertilize a large number of ova; and in man and the mammalia it would appear that a mueh larger quantity is produeed than is absolutely required, a large proportion of it being either lost externally, or remaining in the vagina and uterus unused; only a very small quantity eomes into immediate eontaet with the ovaries. 4. The sperma must eontain spermatozoa. These exist in numbers in the smallest globule of the fluid seareely visible to the naked eye; henee the experiments on artifieial impregnation that have been reported, in whieh this is said to have been aeeomplished with semen freed from animaleules, must be erroneous; there is, in faet, no means of separating the spermatozoa from the semen. 5. There is no invariable mutual relation observable betwixt the quantity of semen and the number of feeundated ova[95].

[95] The experiments of Spallanzani have also thrown much light upon the several particulars now enumerated. The spermatic fluid of frogs, toads, and so forth, will continue to preserve its power for eight hours after the death of the animal; dilution with water, bile, saliva, urine, and vinegar in small quantity, does not destroy the fertilizing power; Rusconi fecundated the ova of frogs with sperma

§ 36. It is impossible to speak of the material relation of the semen to the ovum after or at the instant of fecundation. The ideas of some recent as well as older observers that the spermatozoa penetrated the ovum itself, and were there developed into the embryo or the nervous system of the embryo, are altogether inadmissible. No seminal animalcule has ever been discovered with the aid of the best instrument in the vitellus, stratum vitellinum, &c. of the ovum; nor is it conceivable how these creatures should have power to penetrate the vitellary membrane. Seminal animalcules are indeed found in abundance, and even after they are dead, in the neighbourhood of the yolk-ball, but none within its substance[96]. The possibility of the transudation of the liquor seminis to the stratum vitellinum is not to be gainsaid, though the fact is not demonstrable by the microscope or otherwise. The notion that the vitellus, in the ovum of the frog, to quote a single case, has its peculiar furrowed formation to the end that the spermatic fluid may reach and more easily exert its specific influence on every part of the vitellary substance is unlikely; the furrowed appearance of the surface of the yolk would rather seem to be the effect of fecundation[97].

taken from the bodies of males which were exposed in the market, flayed and ready for dressing; Jacobi fecundated ova with the sperm of a carp which had been dead four days. The temperature has an influence here; the fecundating power continues longer when it is cool. Spallanzani found that the ova of frogs were impregnated when he used three grains of semen diffused in eighteen ounces of water for his experiments; when the same quantity of spermatic fluid was mixed with two pounds of water, the fecundating power was very considerably diminished, and still more so with three and four pounds; but nevertheless, even when the disproportion was so great as twenty-two pounds of water to three grains of semen, several ova were fecundated. The fertilizing influence was the same whether the ova were kept plunged in the spermatic fluid for some considerable time, or only for an instant. Vide Spallanzani for further and still more varied details; also Burdach in his *Physiologie*, and Rusconi in Müller's *Archiv* f. 1835, S. 207. Rusconi found that the ova in the female frog were susceptible of fecundation three hours after the animal had been decapitated.

[96] The statements of the older observers, that the spermatozoa penetrated the ovum, contended for entrance into it, shut themselves up there, and so on, are of course pure fables. Prevost and Dumas in our own times have maintained that the spermatozoa afforded the basis of the nervous system, brain, and spinal cord, and that the rest of the embryo grew to these out of the female generative elements. I have never seen spermatozoa in the vitellus, but many times, and very plainly, in its immediate vicinity; for instance, in the albuminous layer of the fecundated fish's egg. In the last case they had perished.

[97] Rusconi, in opposition to Baer, is correct in viewing the furrowing or wrinkling of the surface of the yolk as an effect of advancing development after impregnation; it is a consequence, not a cause or means of fecundation. Vide Baer in Müller's *Archiv* 1834, S. 48, and Rusconi, loc. cit. p. 207.

§ 37. *Phenomena accompanying the generative act.*

Besides the essential, the necessarily inherent phenomena of impregnation, there is a series of accompanying phenomena, reflections as it were, in other organic systems, which play a secondary part in the generative act. To this series pertain those occurrences which have their ground in a participation of the nervous system, and which in an especial manner accompany the sexual act. It is of importance to have a clear apprehension of these phenomena, as they exert an influence on the due encounter of the generative elements—the ejaculation of the spermatic fluid, and the casting loose of the ova. The nerves of common sensation appear to be almost uniformly in a state of high excitement during the sexual act; an intense feeling of enjoyment is experienced, which mounts continually, and reaches its height at the instant of ejaculation; it is often so powerful, that it is followed by a state of temporary unconsciousness, or the individual yields so entirely to the sensation, that he is no longer susceptible of other impressions. Ejaculation is always an involuntary act; and the muscular action that effects it belongs to the class of motions which have been characterized as reflected[98]; that is, the sensory nerves of the glans penis transmit a peculiar sensation to the brain and spinal cord, and these reflect the impression upon the corresponding muscular parts of the genital system: the scrotum is drawn up tight around the testicles, the vesiculæ seminales and prostate are compressed by the levatores ani, and the spasmodic rhythmical contractions of the perinæal muscles, particularly the bulbo-cavernosi, effect the vigorous ejaculation of the spermatic fluid. This, according to rule, only occurs during the complete erection of the penis, by which it is fitted to penetrate some way, more or less, into the vagina. Erection is accomplished by the swelling of the corpora cavernosa penis, which become distended with blood. Whether the so-called *arteriæ helicinæ* are concerned in the phenomena of erection, or these are produced by simple distention of the venous network of the penis, is not yet determined[99].

[98] On the immediate conditions of reflected motions generally, see the Book on the Nervous System. It may be well to state incidentally in this place, that the whole doctrine of the reflex functions rests entirely upon an hypothesis, which, however, affords the best explanation that can be offered of many phenomena. Ejaculation also follows in coitus without intromission of organs, through the simple stimulation of the nerves of sensation; among animals of the most dissimilar kinds we often observe reciprocal excitement of the genital organs, before the actual performance of the sexual act: birds, fishes, &c. touch or titillate the external genital orifices, &c. &c.

[99] Vide § 26.

§ 38. In the female the sense of enjoyment *sub coitu* appears to be principally excited by the friction of the labia interna and clitoris, which are alike in a state of turgescence or erection: this nervous excitement, as in the male, often reaches such a degree of intensity, that a kind of syncoptic state is induced. The impression made is also reflected on the nervous parts of the internal organs of generation, but the nature and extent of the effects produced on these cannot be appreciated by reason of their situation. In all probability, in consequence of the reflected impressions upon the motory fasciculi of the organic nerves, the os uteri dilates for the reception of the ejaculated spermatic fluid. An increased secretion of the peculiar-smelling mucus of the vagina also takes place [100].

§ 39. The union of the sexes is brought about by the peculiar instinctive feeling or appetite designated the sexual propensity. This appetite has physical grounds as the cause of its normal appearance: the evolution of the male and female generative elements acts as a stimulus upon the germ-preparing sexual system, the nerves of which convey their excitement to the sensorium, where the stimulation becomes consciousness, and imagination is aroused. Imagination, again, may in its turn excite the sexual appetite without physical grounds [101].

§ 40. The various phenomena that usually accompany the sexual act are by no means to be regarded as circumstances essential to its end; they are generally, but certainly not invariably, associated with a prolific union. We have seen that impregnation may be effected in a purely mechanical or artificial way, when of course all the phenomena in question are wanting: women have borne large families, who never felt any satisfaction in the embraces of their husbands; and numerous instances have occurred among men, in which fruitful intercourse has taken place not merely without all sensation of pleasure, but with positive pain; also

[100] Perhaps the rupture of the Graafian vesicle in man and mammalia, the separation of ova from the ovaria in other animals, in consequence of the sexual act, is an action or incident to be referred to this law in the physiology of the nervous system. Vide the observations on reflected motions in the foregoing paragraph.

[101] Examples of purely physical excitement of the sexual propensity may be observed in many morbid irritations of the genital organs and the parts connected with them,—for example, in inflammatory affections of these parts in gonorrhœa, calculus in the bladder, ascarides in the rectum, &c. The occasional instances of strong sexual desire that have been observed in eunuchs, and in children before the age of puberty, indicate the existence of the sexual appetite without normal physical causes. Vide on this point the *Physiology of the Nervous System*, and the *General Physiology*, Book iv.

without actual penetration of the sexual organs, and consequently without that intimate mental and physical communion which ought to accompany commixtion of bodies, and is usually held to be a state necessary to generation. Let but the one essential condition, to wit, the contact between the spermatic fluid and the ovum, be effected (§ 31), and all is fulfilled [102].

§ 41. *Immediate consequences of Sexual Intercourse and Impregnation.*

The most immediate consequence of the sexual act is the loosening of the ova; among some of the lower animals, as among frogs, toads, fishes, &c. this even happens during the act; in other instances it occurs later, as among insects, birds, mammals, and man. The stimulus of the intercourse is felt by the ovary; in the ripe ova, fecundated or fit for fecundation, the germinal vesicle disappears. How this happens, whether in consequence of sudden rupture, or through rapid colliquescence and liquefaction, shrinking together, decrease of contents, or otherwise, cannot be positively determined. It occurs, or may occur, however, before positive fecundation or contact of the semen has taken place [103]. This much is certain, that the germinal vesicle is always found to have disappeared so soon as the ovum is cast loose from the ovary; in rare instances the germinal vesicle is even wanting in every ripe ova still attached to the ovary [104]. The contents of the germinal vesicle, in which, with the increasing ripeness of the ovum, more and more consistent granulations are evolved, at the same time that the germinal macula is often disintegrated or dissolved, are apparently poured out in the space occupied by the germinal layer or germinal disc (§ 17), and from the anatomical position must be deposited in its central part [105]. In the mammalia

[102] Examples of violation of the person, with consequent impregnation, are not rare, but they are inapplicable as illustrations here, inasmuch as the sensations proper to the sexual act are involuntary, and may be aroused at the moment of intercourse; in spite of the utmost extent of moral repugnance and disgust. The absence of the phenomena that usually accompany sexual intercourse is scarcely observed save among women, and is probably owing to some imperfection of physical constitution; these individuals nevertheless, as stated, seem to conceive as readily, and have often as large families as others differently constituted.

[103] For example, in frogs, fishes, &c.—See the earlier paragraphs.

[104] This I have observed in various animals: Baer mentions it in reference to birds.

[105] An increase of this kind in the quantity of granulations, with disappearance of the original macula germinativa, is very distinctly seen in the scaly amphibia,

a certain excitement consequent on the sexual act, perhaps due to the presence of spermatozoa in the uterus, is communicated to the tubes, which with their abdominal extremity approach the ovarium, grasp this body closely by means of their fimbriæ, and receive the ovulum as it escapes from the bursting Graafian follicle [106]. When this has happened, and fecundation follows, development commences immediately, and without any further influence of the engendering individuals. Among other animals, birds for example, a like attraction occurs between the oviduct and the ripe impregnated yolks; but here other circumstances must be superadded, such as oviposition, natural or artificial warmth, and so on, if the evolution of the egg is to proceed. Other consequences of sexual intercourse, consensual phenomena in the nervous system, are not essential to, and have no influence upon fecundation [107].

§ 42. *Superfecundation and Superfœtation.*

It may be assumed as a positive and indisputable fact as regards man and the mammalia, that with fruitful coitus the generative act is closed, and its end accomplished. The rule is, that as soon as ova have been cast loose, the heat ceases in female animals: bitches will not then suffer the approach of the male. Here the instinct ap-

and even in birds and the mammalia, they make their appearance in the shape of pale clear globules. See many of the figures in my *Prodromus*, and that of the rabbit's ovum represented in fig. LXII. With regard to the changes immediately consequent on the disappearance of the germinal vesicle, we are compelled to seek refuge among pure hypotheses; observation has as yet come to no conclusions on this point. The later researches of Schwann appear calculated to lead inquiry into another, and perhaps a more fruitful path than it has yet taken. It is possible, namely, that the germinal vesicle is the parent cell for new cells of the germinal membrane or blastoderma. The new granulations into which I saw the germinal macula of amphibia and fishes separate, are perhaps young cells within the parent cell, [a fact that has been confirmed by Schwann and Dr. M. Barry. See the account of his *Researches*, in subsequent annotations. R. W.]

[106] It has been maintained that Graafian vesicles might burst, and corpora lutea be formed in consequence of the simple stimulus of the sexual act; this is doubtful,—at all events it seldom occurs, and is abnormal when it does. Vide § 33 and § 38. It is extremely rare to find traces of such an occurrence in prostitutes who have never borne children. For an account of the formation of the corpora lutea, and the changes in the follicles, see under the head of Development, § 68.

[107] To this category belong such incidents as lassitude, somnolence, &c. in both sexes after intercourse. Any definite sensations, such as shuddering, unusual enjoyment, &c. &c. as indications or immediate effects of impregnation having occurred in women, are altogether fallacious, and nowise constant.

pears as the pure and immediate expression and effect of the material condition. In the human female it would seem to be otherwise; in her the sexual disposition appears rather to increase during the first weeks after conception has taken place, probably through the influence of the local irritation upon the fancy. If one or a first fruitful connexion be followed shortly afterwards, and *before the formation of the decidua*, by a second, in some rare instances SUPERFECUNDATION may ensue[108]. Once the decidua is formed, and the ovum has reached the uterus, fruitful intercourse is no longer possible, and the cases of SUPERFŒTATION which have been admitted under these circumstances are physiological impossibilities, so that the recognition of such a circumstance ought to be banished from midwifery and legal medicine. The cases described as cases of superfœtation are all referable to twin conceptions, in which one of the fœtuses has perished at some anterior period of the pregnancy, and has been more or less perfectly preserved[109].

[108] The only cases of superfecundation that can be safely trusted, are those in which a woman has had connexion with two men of different races shortly after one another, and has brought twins to the world, a circumstance of which several instances are recorded. Vide Burdach, *Physiologie*, i. 541. Negresses have occasionally produced a mulatto and a negro at a birth: they had had connexion with a European and a negro shortly after one another. Animals with double uteri, such as hares, occasionally furnish examples of the occurrence of superfecundation, if so much may be concluded from the very unequal development of the embryos contained in the two cornua of the uterus. It has been presumed that the same thing must be possible in those females who are abnormally formed and have a double uterus; but in no case of such a conformation has any admissible instance of superfecundation occurred; and it is even highly probable that in such instances a decidua is formed in both halves of the uterus, inasmuch as this membrane, as we shall see by and by, is produced independently of the ovum, and exists even in cases of extra-uterine conception. See further on this point the annotations under § 77.

[109] Concluding from the present state of our knowledge of the physiology of generation, I hold superfœtation to be an impossibility; Siebold of Dantzig is of the same opinion; he relates the case of a young woman twenty-five years of age, who was for the second time delivered of a boy at the full period, and on the third day afterwards, and with the last afterpains, produced a mass of stuff, which on examination proved to be a blighted, flattened fœtus, which might have attained to about the fourth month; it had been compressed between the walls of the uterus and the membranes of the embryo which had attained maturity, and there remained without putrifying, a circumstance of which instances enough have occurred in cases of extra-uterine conception. Siebold is disposed to refer all recorded cases of superfœtation to precipitated or retarded deliveries, or to defective observation. *Journ. für Geburtsh.* Bd. xvii. S. 334.

SECTION THE SECOND.

OF DEVELOPMENT.

STATEMENT OF THE SUBJECT, AND PLAN OF TREATMENT.

§ 43. The study of embryonic evolution forms one of the most difficult portions of physiology. The history of the development of the human embryo, our peculiar subject, is almost wholly unknown to us in its first and earliest periods, and even as regards those that are later there are many gaps still to be filled up. The reason of this lies obviously in the want of opportunity to institute observations in sufficient number on recent human bodies, and in the uncertainty that pervades all researches upon abortive ova, which are for the most part in a morbid state, and are consequently only fitted after long experience and under the guidance of a competent knowledge of the normal condition, to supply data that may be relied on. On these accounts inquirers both of ancient and modern times have had recourse to animals, the development of which obviously resembles that of man, and which afford an easy means of making observations to any extent. The mammalia have the closest affinities with man, and, naturally enough, were thought calculated to afford the best results; but here, too, many difficulties immediately presented themselves,—to place the considerable expense of such inquiries out of the question: the ova of the mammalia are exceedingly small, their passage through the tubes is followed with difficulty, the epochs of the first stages of their developement are not duly known, and even appear to differ in different individuals, and then the several orders and genera of animals vary so much in many parts of their development, that new difficulties arise in the way on this account. In the class of birds many of the obstacles we encounter among the mammalia are wanting, or at least do not present themselves nearly to the

same amount as in quadrupeds. Among vertebrate animals, too, birds in their mode of development approach the mammalia most closely; the evolution of the bird and mammal in its type and essence is precisely the same. On this account all the older as well as later observers, whose discoveries form epochs in the history of development, have made the evolution of the embryo of the bird the first and most particular subject of their studies. As the common domestic fowl is the bird the eggs of which are most easily procured, and also the most readily hatched, so it is upon the development of the embryo of the fowl that we possess the most extensive and complete series of observations[110].

§ 44. In the following section we shall pursue the plan which seems best calculated for instruction. Whoever would work out a knowledge of the development of animals generally for himself, must begin with the study of the chick, were it only for the reason that we possess the best descriptive works upon this portion of the subject. We shall therefore start with a connected exposition of the history of the brooded egg; and then follow with an account of the evolution of the human embryo, referring constantly to what has already been observed in the chick, and illustrating the earlier stages, and particular obscure or difficult points, by comparative references to the development of the mammalia. From the history of the development of other animals, we shall only select so much as throws particular light upon individual relations of the human embryo, and supplies resting-places in our progress through the study of the laws of our evolution[111].

[110] The value of the study of the embryo of the bird to the history of development is well expressed by Valentin :—" Unquestionably the class of birds is the centre around which all observations on development arrange themselves, and this not so much on account of any grounds intrinsic to this class, as by reason of extrinsic circumstances which are completely under our control. In no other class of animals do we possess the same facilities of procuring embryos in the various stages of their progress. Nowhere can we multiply and repeat our inquiries to the same extent as here. It was on this account that Fabricius ab Aquapendente began his investigations with the brooded egg, and that Harvey and Malpighi followed in the same course; it was in the egg that Wolff made his important discoveries in regard to the formation of the intestinal canal, of the blood, of the extremities and of the kidneys ; and it was by the study of the embryo of the common fowl that Doellinger and his school in our own day were enabled to give a permanent foundation to the history of development as a science. The bird must, therefore, and on these grounds, be made the starting-point for all future inquiries, the norma and basis to which insulated facts in the development of mammalia and man must be referred." *Handb. d. Entwickelungsgeschichte;* Vorrede, S. x.

[111] The most complete, connected, and systematic exposition we possess of the

CHAPTER I.

HISTORY OF THE INCUBATED EGG. DEVELOPMENT OF THE CHICK.

Appliances.—Historical matters.

§ 45. The best season for studying the development of the chick is the spring, when fertile and fresh-laid eggs are to be had everywhere; they may be brought forward by artificial warmth, or by being set under a hen. The latter is the more advisable means for those who are otherwise fully occupied, and cannot give the attention necessary to maintain an equable temperature in the hatching machine. Hatching machines are found of various construction; generally they are double drums or vessels of tinned iron, lined or

history of the development of organized beings—of vegetables, animals, and man—is to be found in the *Physiology* of C. F. Burdach, ii. 2nd ed. 1837, with additions and contributions from K. E. von Baer, H. Rathke, E. H. F. Meyer, K. Th. von Siebold, and G. Valentin. The Manual of the History of Development (*Handbuch der Entwickelungsgeschichte*, 8vo. 1835) of the last-named writer is also very complete, and contains an excellent bibliography of the whole subject. In addition, the various papers and memoirs of v. Baer, Rathke, and Carus—men who have each contributed more or less to our stock of knowledge in regard to the development of all classes of animals—ought to be consulted. On the development of individual organs, Meckel, Rathke, Müller, Huschke, and others have particularly distinguished themselves. The several works in which their observations are contained, will either be referred to in their places under the appropriate paragraphs, or will be indicated in our later Books. [The papers of Dr. Allen Thomson in the Edinburgh *New Philosophical Journal*, vols. for 1830 and 1831, may also be referred to]. The third fasciculus of the Plates illustrative of comparative anatomy (*Erläuterungstafeln zur vergleichenden Anatomie*) of Carus may be mentioned as a general atlas illustrative of development in every class of animals. The following chapters give nothing more than a summary exposition of the History of Development. It is not even the business of an elementary treatise of physiology to follow out this subject to its remotest details, and to particularize the origin and progress of every individual organ. This rather falls within the province of general anatomy, and all the later manuals of this science include it. See particularly the edition of Hildebrandt's Anatomy by Weber, the Manual of Lauth and others. Burdach has exhausted the subject,—he has given all that is known upon it in the place indicated. In our Physiology of nutrition, of sensation, and of motion, the origin and evolution of the several organs concerned in these functions will, according to circumstances, be found referred to more particularly.

loosely filled in the inside with down, wool, or paper-shavings, among which the eggs are disposed, the space between the outer and inner wall being filled with water, and the whole kept at the proper temperature by an oil or spirit-lamp. The proper temperature is from 100° to 104° F.; a degree or two more hastens the development; above 110° F. the embryo commonly perishes; at 95° F. it is developed more slowly. In Egypt the poultry-yard is generally supplied from eggs hatched in ovens constructed for the purpose, which have been imitated in France, but do not appear to have come commonly into use there[112].

§ 46. *History.*

Access to good descriptions and faithful representations is almost indispensable in studying the history of development; yet are we still without any complete collection of figures true to nature of each stadium of this process, and of the different organs in their successive stages of evolution; fragmentary, and, in part, admirable representations, however, we can boast, both of remoter and more recent times. Among the earlier observers, Fabricius ab Aquapendente and Malpighi must be particularly mentioned; in the last century Haller, and still more Wolff, obtained great credit for their researches. The first scientific and complete series of observations, in which many thousand eggs were used, was made by Döllinger, Pander, and D'Alton. The researches of Von Baër form a new epoch in the history of development, as his work is also the most complete we possess on the subject. Particular por-

[112] To take a general view of the history of the development of the chick it will suffice to employ a couple of fowls sitting at the same time, on from a dozen to fifteen eggs each, according to the size of the fowl and of the eggs. The date, hour, and day, when each egg is set must be written upon it, and as one or more are removed for examination, one or more properly inscribed are substituted for them. In this way eggs of the most different dates are soon at command. It is only necessary, in substituting fresh eggs for such as are taken away, to warm them slightly by holding them for a short time in the hand, otherwise the fowls are apt to become restless, and even to forsake the nest. Four or five eggs ought to be left to come out. Baumgärtner in his *Observations on the Nerves and the Blood (Beobachtungen, &c.* Freib. 1830) has described a very simple brooding apparatus. Coste and Delpech in their *Recherches sur la Formation des Embryons des Oiseaux,* Paris, 1834, have described and figured another and more complicated machine. On the influence of different temperatures see Von Baër in his *History of Development (Entwickelungeschichte,* I. 2).

tions of the history of development,—the evolution and growth of individual organs or systems, &c., have been worked out with success by more than one physiologist in very recent times [113].

§ 47. *Structure of the egg as just laid.*

The egg of the common fowl is surrounded externally with a hard calcareous *shell* (fig. XX. *a*), which consists almost wholly of

[113] The posthumous tract of Fabricius, *De formatione Ovi et Pulli,* makes part of his collected works, *Opera omnia,* fol. Lips. 1687, and better in the edition by Albinus, fol. Leid. 1737. The figures are pretty numerous, but rude, and no longer of any use. On the other hand the many representations of Malpighi in his tracts *De Ovo incubato* and *De Formatione Pulli in Ovo (Opera omnia,* fol. Lond. 1686) may still be referred to, particularly if they be viewed along with the admirable commentary of Döllinger in his academical programma entitled, *Marcelli Malpighii Iconum ad historiam Ovi incubati spectantium censuræ specimen,* 4to, Wirceburgi, 1818. Haller's researches bear principly on the formation of the heart: *Deux Mémoires sur la Formation du Cœur dans le Poulet,* Lausanne, 1758; the same work appeared, very much extended, in his *Opera Anatomica Minora,* 3 vols. 4to, Lausanne, 1766. The study of the works of Casper Frederick Wolff must be recommended to every one. They are as follows :—*Theoria Generationis,* ed. nov. 8vo, Halæ, 1774, which is accompanied by two plates containing several figures of the chick in different stages of its development; *De Formatione Intestinorum, &c.,* in *Nov. Commentar. Acad. Petropolitanæ,* tom. xii. (1767), continued in tom. xiii. (1768). The Essay on the formation of the Intestines

FIG. XX.

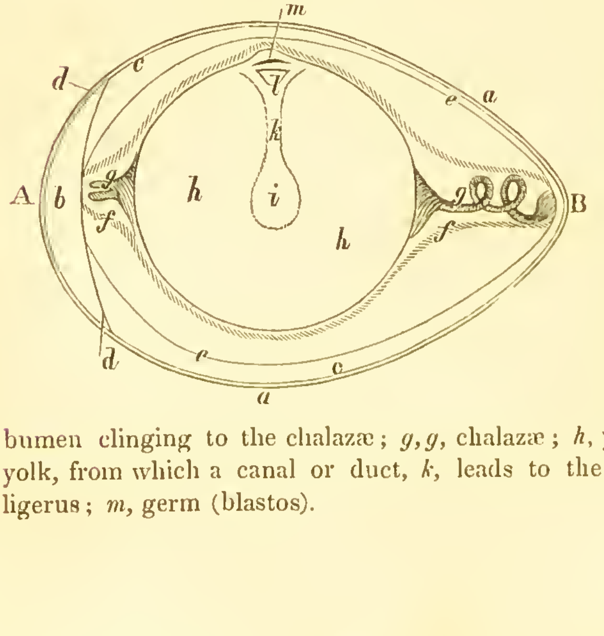

FIG. XX.—Ideal section of an extruded hen's egg, with slight alterations from Baër (*Entwickelung. der Thiere,* B. I. Tab. III) *A*, blunt pole; *B*, sharp pole; *a, a,* shell; *b,* space filled with air; *c,* membrane of the shell, which at *d, d,* splits into two layers; *e, e,* limits of the second and thicker albumen; *f, f,* limits of the third and thickest albumen clinging to the chalazæ; *g, g,* chalazæ; *h,* yolk; *i,* central cavity of the yolk, from which a canal or duct, *k,* leads to the cicatricula; *l,* cumulus proligerus; *m,* germ (blastos).

carbonate of lime. It is indeed without obvious pores, but is nevertheless permeable to air: some part of its watery constituent escapes during the process of hatching, and eggs that are covered with a coat of varnish die. Internally the shell is full of pits or depressions, in which small warty or shaggy processes of the lining *membrane of the shell* (the *membrana testæ*) are implanted (fig. XX. *c, c*). This membrane consists of two laminæ, the outer of which is made rough and uneven by the processes just mentioned; the inner, which is turned towards the white, is smooth and polished. The two laminæ separate at the blunt end of the egg (fig. XX. *d, d*), so that here they are most easily demonstrated, and contain the air-space, or *air-chamber (folliculus aëris)* between them, which first appears shortly after the egg is laid, and is very much enlarged by keeping and the heat of incubation. The membrane of the shell is formed of a compact fibrous tissue, and shows the chemical properties of coagulated albumen. Betwixt the membrane of the shell and the yolk is interposed the *white* (*albumen ovi*), the outer stratum of which (fig. XX. between *c* and *e*) is extremely watery and fluent, and consequently readily drained off when the shell is pierced; the inner layer, again, or that which lies nearer the yolk, is more viscid and thicker (fig. XX. between *e* and *f*), clings more closely to the yolk, especially by its inmost stratum, which immediately surrounds that part and the chalazæ

exists translated into German by J. F. Meckel, *Ueber die Bildung des Darmkanals, &c.*, Halle, 1812, with two plates. The best and most complete collection of figures we yet possess is that contained in the work of Dr. Pander, *Contributions towards the History of the Development of the Chick in the Egg (Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie*, fol. Würzburg, 1817). The plates are by D'Alton, senior, and masterly in point of drawing. The work more particularly embraces the evolution during the first five days. The figures in the *Dissert. sistens Ovi Avium historiæ et Incubationis prodromum*, 8vo. Jenæ, 1808, by the Count von Tredern, are particularly neat in their execution, and extremely correct. Completeness of description was the object aimed at by Von Baër in his classical work entitled *Observations and Reflections on the Development of Animals, (Zur Entwickelungsgeschichte der Thiere, Beobachtung und Reflexion*, vol. i. 1828, vol. ii. 1837), and this he has fully attained. The extreme minuteness of this work, however, makes its study somewhat difficult, so that perhaps the compendious view or abridgment to be found in the second volume of Burdach's *Physiology*, is more to be recommended to beginners. The schemes or ideal sections of the chick given in both works are extremely useful in facilitating the comprehension of the subject. The figures of Coste and Delpech (op. cit. annot. 112) are in part incorrect, in part good. The figures incorporated in this work from fig. VIII. to fig. CXXVIII. supply whatever is most important to the illustration of the following descriptions, and are constantly referred to within brackets. I have followed Baër wherever it was possible to do so.

(XX. *f, f*). The white of an egg shows alkaline reaction, and contains albumen, salivary matter, and the common sulphates and hydrochlorates in small quantity. The *chalazæ* (XX. *g, g,* XXIII. *b, b*) are a couple of spirally-twisted ropes, composed of delicate fibres, or of a fine membrane, which, as the chalaziferous membrane (*membrana chalazifera*) closely surrounds the yolk, and then going off in the fashion of a funnel towards either pole of the egg, becomes twisted into a rope. (figs. XX. XXI. and XXIII.) A white streak, in the shape of a band, may usually be seen extending over the yolk from one chalaza to the other; this is the zone, or belt (*zona*), which, however, is not constant, and is of no particular importance. The chalazæ vary exceedingly in point of form and development; they appear to consist of coagulated albumen. The *yolk*, or *yolk-ball* (*vitellus*,) is somewhat lighter than the white, so that, in whatever position the egg is held, it always rises towards the side that is uppermost. The *vitellary membrane* (*cuticula vitelli*), (fig. XXII. *a*, fig. IX. *c*,) is a perfectly simple, transparent, and slightly glistening membrane. It surrounds the yolk (which with its central cavity, figs. IX. and XX. *i*, has been already particularly described, § 17) closely and immediately. Immediately under the vitellary membrane, and at a point which in an opened egg is always directed upwards,

Fig. XXI.

Fig. XXI.—One of the chalazæ of the Jackdaw's egg pulled straight. The way in which the twisted fibres of the part diverge into a funnel-shaped expansion as they approach the yolk, and so form the innermost stratum of the albumen, is displayed.

Fig. XXII.

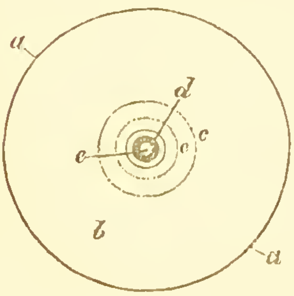

Fig. XXII.—Vitellus, or yolk of a hen's egg, seen from above: *a, a,* vitelline membrane; *b,* vitellus; *c, c,* halones; *d,* darker, more external part of the germ (the future area vasculosa); *e,* central transparent part of the germ (the future area pellucida). In the yolk here figured, the first slight effects of incubation are apparent, viz. in the separation in the germ, which often takes place from transient exposure of the egg to a high temperature (handling), or when the eggs have been laid some time and the temperature of the air has been high.

the *cicatricula* (fig. XXIII. *A, c,* and B), or tread, is seen shining through in the shape of a round whitish spot. The cicatricula consists superficially of a membranous stratum (stratum proligerum,—fig. XXIII. *B*), from a line and a half to two lines in diameter, in which the germinal vesicle was imbedded at an earlier period (§ 18). This is the *germ,*—blaste, s. blastos, from which in the beginning of the brooding the *germinal membrane,* blastoderma, is produced (fig. X. *A, b,* p. 40). The germ in recent eggs is generally slightly adherent to the vitellary membrane; in such as have been kept for some time, it is more detached; under all circumstances it is readily diffluent, little consistent. In the centre it is somewhat clearer and more transparent than elsewhere (fig. XXII. *e*), and allows the *germinal cumulus,—cumulus proligerus,* s. *nucleus cicatriculæ,* s. *nucleus blastodermatis,* also the *stratum proligerum* of Baer,—to be seen through it (fig. X. *A, d,* p. 40). This germinal cumulus is a loose whitish-yellow, and somewhat conically formed granular layer (fig. X. *A, d,* p. 40), sunk in the substance of the yolk; betwixt it and the discus proligerus, or germinal disc, there is a minute interval which is filled with a fluid that appears to communicate with the canal of the central cavity of the yolk [114].

[114] In the foregoing description and terminology, I have felt it my duty to follow Baer as closely as possible. Vide his 2nd vol. p. 10, et seq. On the chemical composition of the egg, see Berzelius, *Animal Chemistry* (*Thierchemie,* 1831), p. 537. The white consists of from 12 to 13 parts albumen, 85 water, 3 soda, common salt, and an extractiform matter; according to Bostock, it also contains salivary matter in considerable quantity, sulphates, and muriates; the

FIG. XXIII.

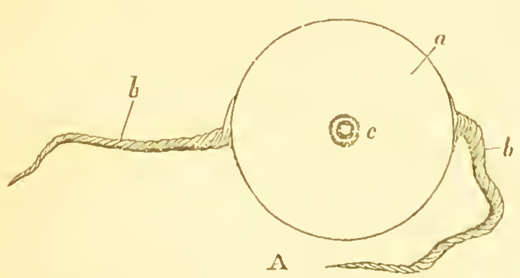

Fig. XXIII.—A, the unincubated yolk of the Jackdaw's egg *(corvus corone)*; *a*, the vitellus; the chalazæ, *b, b*; the cicatricula, *c*.
B, the cicatricula magnified.

§ 48. *Detachment of the ovum from the ovary, and completion of its formation in the oviduct.*

Wc have alrcady spoken (§ 16) of thc ehorion, or outer-eovering of the ovum in the ovary, coaleseing with a layer of thc ovarian stroma into a firm eapsule or theea (fig. IX. *a*, p. 38). This capsule is surrounded externally with cellular tissue and blood-vessels, and is partieularly thiek in that part of its eireumferenee towards the pediele (fig. IX. *b*). The yolk, or vitelline-ball, lies within this capsule, and as it advances to maturity forms a more and more eompletely pedieulated growth, like a berry, of whieh every ovarium presents many in different stages. (fig. XXIV.) On that side of eaeh capsule, or berry, which is opposite the pediele, a curved, pretty broad, white streak is observed; this is the *cicatrice*, (*stigma*), (fig. XXIV. *b*), whieh appears not to be vascular, for although the blood-vessels that enter by the pedicle form a conspicuous rete with rhomboidal meshes on every other part of the

alkaline reaction, Dr. Bostock also informs us, depends on the presence of free soda. The space which is filled with air, Bischoff says, contains a somewhat larger proportion of oxygen than the atmosphere.

[Dr. Paris published an analysis of this air in the year 1809.—*Trans. Linnæan Society*, vol. x. Before incubation it was atmospheric air; towards the end of the incubation it was the same air, but contaminated with a small portion of carbonic acid gas. R. W.]

Fig. XXIV.

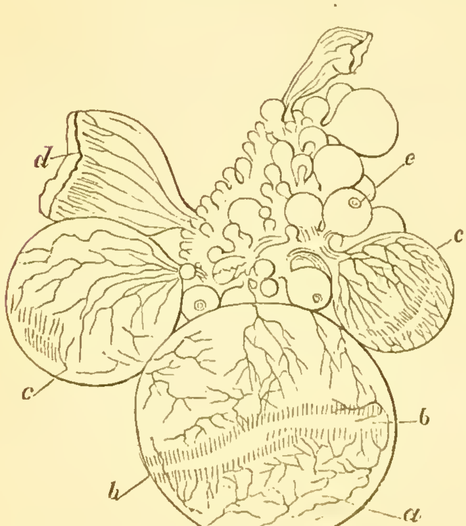

Fig. XXIV.—Ovary of the Fowl, with vitelli or yolks, ripe and approaching maturity :—*a*, a ripe yolk within its calyx or cup, the cicatrice of which, *b, b*, is seen as a transverse vesselless streak ; *c, c*, smaller yolks with the vascular rete of their cups and their cicatrices ; *d*, a calyx empty, the part having given way along the line of the cicatrice ; smaller yolks (*e*,) are enveloped by calices so transparent that the cicatricula is seen through them.

capsule, none is seen to cross or to penetrate the cicatrice. The capsule is thinnest at this point, and the yolk is here in most intimate contact, or even appears to be connected with it (fig. IX. at the lower part); the capsule at length gives way, yielding in the line of the cicatrice, and forming a transverse rent with double flaps, through which the yolk escapes. The rupture of the capsule in the line of the cicatrice is easily effected by slight pressure, even in ova that are far from maturity (fig. XXIV. *d*); it happens naturally to the ripe ova after impregnation. When the yolk has escaped, the capsule which had inclosed it presents itself as a hollow membranous funnel, the *calyx* (fig. XXIV. *d*), which remains hanging by its pedicle, and shrivelling up or shrinking into the stroma of the ovary, soon leaves no trace of its former existence. The detachment of the vitellus is accomplished either by the perfected growth of this body, its size proving sufficient at length to burst the cicatrice, or by an increase in the thickness of the capsule towards the pedicle, by which the vitellus is forced as it were against the cicatrice (fig. IX.); the whole process is very similar to that which occurs among the mammalia when the Graafian vesicle gives way and the corpus luteum is formed (vide § 67). The oviduct attaches itself, by a kind of suction, by its patulous infundibulum or bevelled abdominal end to the capsule which contains the ripest ovum, and receives this as it escapes. From this point the ovum makes its way moving spirally along the muscular oviduct, which is now very much enlarged, highly vascular, and pouring out from its mucous surface the albumen which is disposed around the yolk in the different layers but just described. The formation of the chalazæ is a consequence of the rotatory motion upon its axis which the ovum receives in the oviduct, and of the setting of the albumen. The lower part of the oviduct is dilated into a receptacle for the egg, and here are added the membrane of the shell, and finally the shell itself, the milky calcareous fluid secreted by this part being precipitated upon the egg in crystals, which are at first isolated, but very soon run together and cohere. The egg remains over twenty-four hours in the receptacle. The germ at the first entrance of the egg into the oviduct has already assumed the appearance proper to it at any period anterior to the commencement of incubation, the germinal vesicle having burst; the upper disciform layers of the germ and germinal cumulus only separate more and more. After the egg is thus perfected, it is forced rapidly through the cloaca. In other birds, it is here perhaps that the egg receives in part at least the beautiful

colours, red, green, yellow, brown, &c., in various shades, which are so frequently met with, and which appear to be so many tints of the colouring matter of the blood chemically altered [115].

Earliest period in the development of the Chick, from the first appearance of the Embryo to the first traces of circulation.

§ 49. The first period in the development comprehends about two days. In the first hours of incubation, the germ separates itself more from the vitellus and vitellary membrane, to which, however, it still continues in some sort attached; the germ acquires more of a membranous consistence, and the space between it and the germinal cumulus, which is filled with fluid, becomes somewhat larger (fig. X. *A*, p. 40). Towards the sixth, or between that and the eighth hour, a parting or resolution in the now foliaceous germinal membrane, which proceeds from the centre towards the periphery, is apparent ; a clear rounded space, about a line in diameter, is produced in the middle, this is the *area pellucida* s. *germinativa*,—the pellucid or germinal area (fig. XXII. *e*) ; the germinal membrane at the same time becomes darker in the circumference, and surrounds the transparent pellucid area like a ring, which is also about a line in breadth (fig. XXII. *d*) ; this is the future *area vasculosa*, or vascular area. The *cumulus proligerus* is seen in the deeper parts shining through the centre of the germinal membrane. At this time two or three annular lines appear drawn around the circumference of the germinal membrane,—the *halones* (fig. XXII. *c*, *c*) ; these are circular ridges or walls formed in the vitellus, between which there are furrows filled with thinner fluid. Now also the germinal membrane may be observed to show a disposition to separate into two layers, which are indeed still intimately connected, but even at this early period are in point of structure different. They are always particularized as the *laminæ* of the germinal membrane, the superior lamina being entitled the *serous* or animal *layer*, the inferior the *mucous* or vegetative *layer* ; the former is limited to the extent of the area pellucida, the latter extends farther in the periphery, stretching beyond the area vasculosa. The albumen disappears in a great measure over the germi-

[115] Vide the more particular details in v. Baer, and in my *Elements of Comparative Anatomy ;* also the beautiful figures in Carus's *Plates illustrative of Comparative Anatomy*, pt. 3. (Erläuterungstafeln) pl. viii. and the text, containing physiological observations on the origin of the colours of the eggs of different birds.

nal membrane, and the vitellus approaches the lining tunic of the shell more closely; in this situation, the vitellus becomes more prominent, forming a segment of a lesser sphere, like the cornea of the eye; a circumstance which may likewise be frequently observed in the egg before incubation (fig. XX. over *m*). It is not unimportant to observe that these, the earliest observable changes not unfrequently take place in eggs that are laid in summer and when the weather is very warm, though of course much short of brood-heat.

§ 50. About the middle of the first day, after from twelve to fifteen hours of incubation, the *blastoderma*, or germinal membrane, is completely detached from the vitellary membrane, and may be cut out as a connected lamina, and washed away from the membrane of the yolk (fig. XXV. and XXVI.). The *germinal area* (*area pellucida* s. *germinativa*) has now an elongated, often a somewhat pyriform appearance (figs. XXV. and XXVII. *b*), and is two lines in length. The darker *vascular area* (figs. XXV. and XXVII. *c*) has

Fig. XXV.

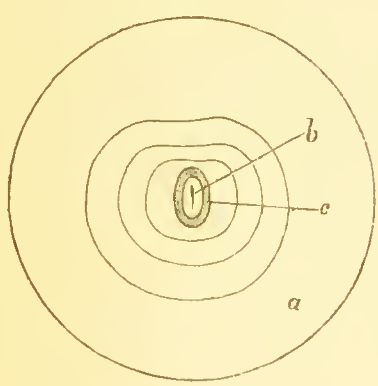

Fig. XXV.—Vitellus or yolk after from twelve to fourteen hours incubation, of the natural size (this and the other figures of the vitellus look larger than proper, from their having been placed in flat saucers to be drawn, by which they become somewhat flattened): *a*, the yolk; *b*, area pellucida, in the middle of which the *nota primativa*, or primary streak, the first trace of the embryo, is perceived; *c*, outer area pellucida, the future area vasculosa. The halones are indicated by the three concentric circles.

Fig. XXVI.

Fig. XXVI.—The same vitellus, but with a piece of the vitellary membrane and the subjacent blastoderma removed at *a*, by which the nucleus of the cicatriculæ, or cumulus proligerus, a dark housed disciform substance implanted in the vitellus, is brought into view.

also lengthened out, and the germinal membrane extends as a foliaceous formation indefinitely over it into the halones, which now begin to look less regular than they were originally. This outer portion of the blastoderma is called the *area vitellina.* About this period also the separation of the blastoderma, in the direction of its thickness, becomes more apparent; between the serous layer, which still continues limited to the germinal area, and the mucous layer, which extends into the vitelline area, there appears a new lamina, which, however, is only distinctly defined towards the periphery, where it approaches the limits of the area vasculosa; in the direction of the thickness this lamina lies in the blastoderma as if it belonged to both of the other layers, and penetrated into their substance; to distinguish this less separated lamina, it is spoken of as the *vascular lamina,* the blood and blood-vessels first making their appearance within its substance. This formation first becomes distinctly visible between the sixteenth and twentieth hour of incubation (fig. XXXI. *A, B, d*). Somewhat earlier than this, namely, about the fourteenth hour, the first rudiments of the embryo become distinctly visible in the middle of the germinal area, in the guise of a delicate white elongated streak, about a line and a half in length; it is designated *nota primitiva*—the primitive streak, and lies in the line of the long axis of the germinal area, which itself lies in the transverse axis of the egg (fig. XXVII. *a*). Under the nota primitiva, the cumulus proligerus, deeply seated, may still be seen very plainly glistening

Fig. XXVII.

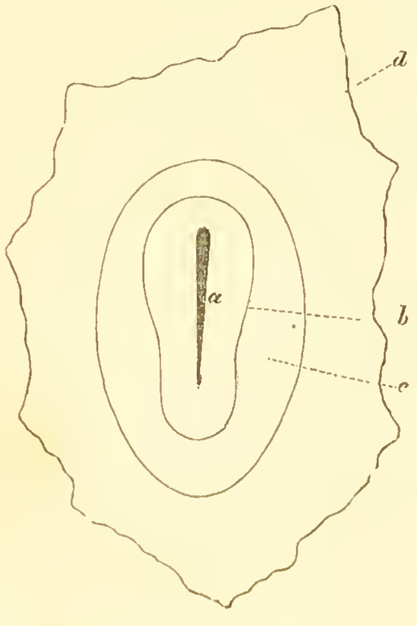

Fig. XXVII.—Magnified view of the portion of the blastoderma removed in fig. XXII.—*a*, the nota, or primary streak; *b*, the oblong area pellucida; *c*, the oval area vasculosa.

through (fig. XXVIII. *A, B, d*). The nota primitiva rises slightly above the level of the germinal area (fig. XXVIII. *b*); it is thicker and blunter anteriorly, or towards that end which becomes the head of the embryo, thinner and tending to a point posteriorly. The nota primitiva is probably the groundwork of the brain and spinal cord[116].

§ 51. The nota primitiva, an aggregate of dark granules in the first instance, becomes more fluent by and by, and presents itself as a layer of delicate, transparent masses, by the side of which, between the sixteenth and eighteenth hour, a pair of new formations arise symmetrically, near the middle line. These are the *laminæ* s.

[116] In my view of the relations of the nota primitiva I differ from Baer, who regards it as the forerunner of the vertebral column, which speedily disappears again, whilst to me it seems only to undergo histological metamorphosis—*i.e.* to suffer change of structure in the course of its development.

[According to Reichert (*Entwickelungsleben im Wirbelthierreich*, 4to. Berl. 1840), the nota primitiva in the ovum of the frog is not raised, it is on the contrary depressed—a furrow or channel (S. 105); neither is it the rudiment of any part, but a mere indication and effect of a certain amount of formative process achieved, this process having reference to the primary halves of the central nervous system. R. W.]

Fig. XXVIII.

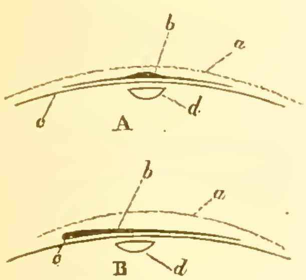

Fig. XXVIII.—Ideal sections of fig. XXV. (after Baer, with slight variations).—*A*, transverse section; *B*, longitudinal section; *a*, vitelline membrane, indicated by a finely dotted line; *b*, nota, or primitive streak, with the serous layer of the blastoderma, corresponding to the area pellucida; *c*, mucous layer of the blastoderma, corresponding to the area vasculosa; *d*, cumulus proligerus s. nucleus cicatriculæ.

Fig. XXIX.

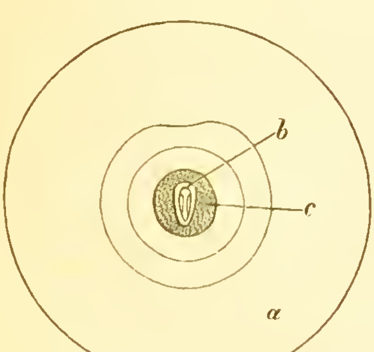

Fig. XXIX.—Yolk of the natural size, after eighteen hours of incubation: *a*, vitellus; *b*, area pellucida; *c*, area vasculosa.

plicæ dorsales—the dorsal laminæ, two eylindrieal rolls or enlargements, whieh arise parallel to the nota primitiva, and form a eouple of eristæ, or ridges, one on either side of it (fig. XXIX. and XXX. *b, b*), whieh diverge anteriorly and posteriorly, being nearest about the middle of their length, and sloping somewhat from without inwards, or towards one another. The angles of the ridges are softly rounded off; eaeh ridge has the appearanee of a elear broad line, whieh is ineluded within two darker lines. The germinal area presents a pyriform outline (fig. XXIX. and XXX). Under the eanal for the spinal eord, whieh is bounded by the dorsal laminæ, we observe the *chorda dorsalis*—the dorsal eord (fig. XXXI. and XXXIV. *A, e,* and fig. XXXIII. *f*), an extremely fine elongated streak, surrounded by a transparent sheath; both the dorsal eord and the sheath go to eonstitute the eartilaginous eolumn whieh appears later, and out of whieh by its beeoming divided into pieees, the vertebral eolumn is produeed. The embryo with its laminæ dorsales now bends itself forward, at the same time that it here forms a siekle-shaped transparent fold (fig. XXX. *c*), the future *involucrum capitis*—the eranial envelope or eap. From the

Fig. XXX.

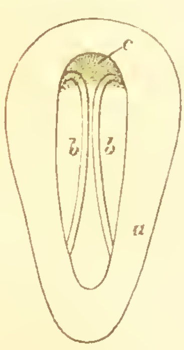

Fig. XXX.—The pellueid area of fig. XXIX. magnified: *a*, the pellueid area, now beeome pear-shaped; instead of the nota, or primary streak, the two dorsal laminæ or folds (*laminæ* s. *plicæ dorsales*) *b, b,* are seen; the involucrum eapitis, or cranial envelope, *c*, a faleiform fold, or kind of reflex blastoderma, begins to be developed.

Fig. XXXI.

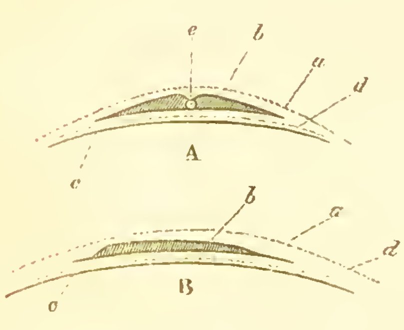

Fig. XXXI.—Ideal seetions of figs. XXIX. and XXX.—*A*, tranverse seetion; *B*, longitudinal seetion; *a*, vitellary membrane; *b*, serous layer of the blastoderma, or germinal membrane, depressed in the middle by reason of the rounded elevations of the dorsal laminæ on either side; *e*, ehorda dorsalis; *c*, mueous layer of the blastoderma; *d*, vaseular lamina, between *b* and *c*, indieated by a finely-dotted line.

twentieth to the twenty-fourth hour, the transparent germinal area is observed to become longer and more fiddle-shaped. The cristæ, or folds of the dorsal laminæ, where they run closest together, appear somewhat sinuously bent (fig. XXXIII. *b*, *b*); here, too, in the pectoral region, on both sides of the dorsal laminæ, near their cristæ, there appear dark, four-cornered looking plates, the future vertebral arches (fig. XXXIII. *c*, *c*, fig. XXXIV. *A*, *f*), which form at first but three or four pairs; the cristæ of the dorsal laminæ are observed to approximate more and more, in order to close and complete the vertebral canal (fig. XXXIV. *A*, over the chorda dorsalis, *e*). Anteriorly they separate to a greater extent from each

Fig. XXXII.

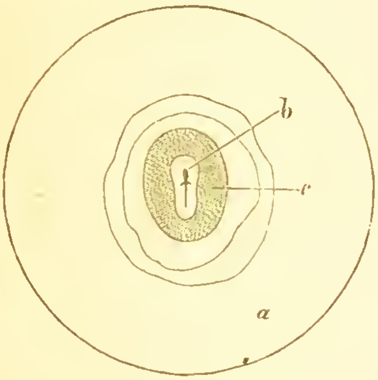

Fig. XXXII.—Vitellus of the natural size after twenty-four hours of incubation, the germinal membrane with the rudiments of the embryo farther advanced than in fig. XXIX. The references are the same in this as in that figure.

Fig. XXXIII.

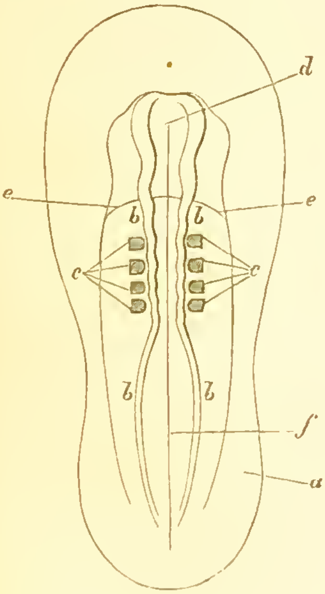

Fig. XXXIII.—Magnified view of the pellucid area of the yolk, fig. XXXII; the area has now lost its pear-shape in a great degree, and become somewhat fiddle-shaped (biscuit-shaped in the original). In the middle are seen the slightly sinuous edges of the dorsal lamina, *b*, *b*, separating from one another anteriorly and posteriorly; on their outsides lie four square plates, *c*, *c*, rudiments of the vertebral column; *d*, anterior cerebral cell; *e*, *e*, transparent edge of the cranial involucrum, shining through; *f*, dorsal cord.

other to form the head (fig. XXXIII. *d*), and also posteriorly to form the future saerum; the enveloping fold, the future involuerum eapitis, is thrown farther back (fig. XXXIII. *e*, *e*); the vaseular and mueous laminæ of the germinal membrane follow this bending in (fig. XXXIV. *f*), by whieh the beginning of the intestinal eanal is produeed, which as yet is nothing more than a depression on the vitelline side of the serous lamina of the germinal membrane. The embryo lies like a flat-bottomed boat turned over upon the germinal membrane (fig. XXXIV. *B*); the head is already strongly indicated (fig. XXXIV. *B*, *e*) [117].

§ 52. With the seeond day of ineubation the embryo diseonneets itself ever more and more from the germinal membrane and the yolk, and rises more distinetly over the germinal area. This takes plaee by the anterior plait or fold (*involucrum capitis*), eon-

[117] Baer views several of the appearances otherwise than as they are described in the text. Aecording to him the brain and spinal marrow are wanting upon the elosure of the dorsal laminæ; they would appear to be actually present, however, only in a perfectly transparent and fluid eondition; they seem to arise out of a metamorphosis of the nota primitiva. The ehorda dorsalis with its sheath is only to be well observed on a transverse seetion (figs. XXVIII. XXXI. XXXIV. *A*, *e*), and not by viewing the germinal membrane from above, when it only presents itself as a simple streak (figs. XXXIII. and XXXVI. *f*), as if it were the ideal axis of the vertebral eolumn. It disappears completely with the development of the bodies of the vertebræ. In figure XXXIII. the sinuous erumpling and the distance of the eristæ of the dorsal laminæ, are more strongly expressed than they appear without any preparation; the germinal membrane had been here examined under the surface of warm water, by whieh the particulars mentioned eame out in stronger relief. Baer believes that the nota primitiva divides shortly after its formation into two lateral halves—the dorsal laminæ, and a middle streak—the dorsal ehorda, a view in which I eannot agree with him.

FIG. XXXIV.

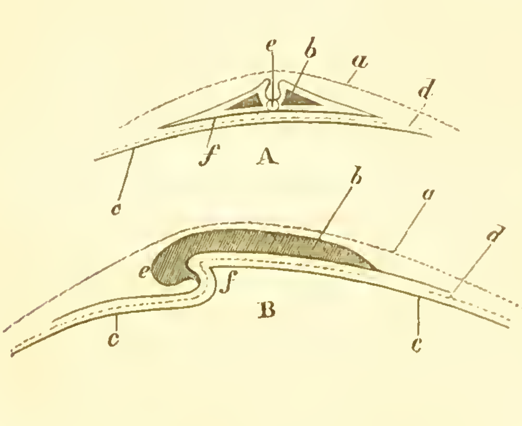

Fig. XXXIV. — Ideal seetions of fig. XXXIII. — *A*, transverse section; *B*, longitudinal section. In *A*. *f*, seetion of the vertebral laminæ. In *B*, formation of the head by the reflexion of the blastoderma; *e*, margin of the involuerum eapitis, and entranee into the future intestinal eanal (fovea eardiaca of Wolff). The other references are the same as in fig. XXXI.

tinuing to recede still farther backwards (fig. XXXVI. *e*), and the development posteriorly of a second plait or fold, sickle-shaped or

Fig. XXXV.

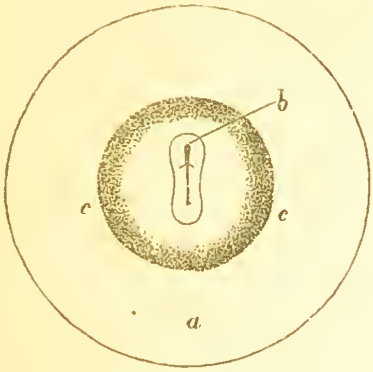

Fig. XXXV. — Yolk of the natural size after thirty-six hours of incubation: *a*, yolk; *b*, fiddle-shaped pellucid area, in the middle of which the embryo is seen. In the vascular area, *c*, *c*, the insulæ sanguinis, or blood islets, begin to appear.

Fig. XXXVI.

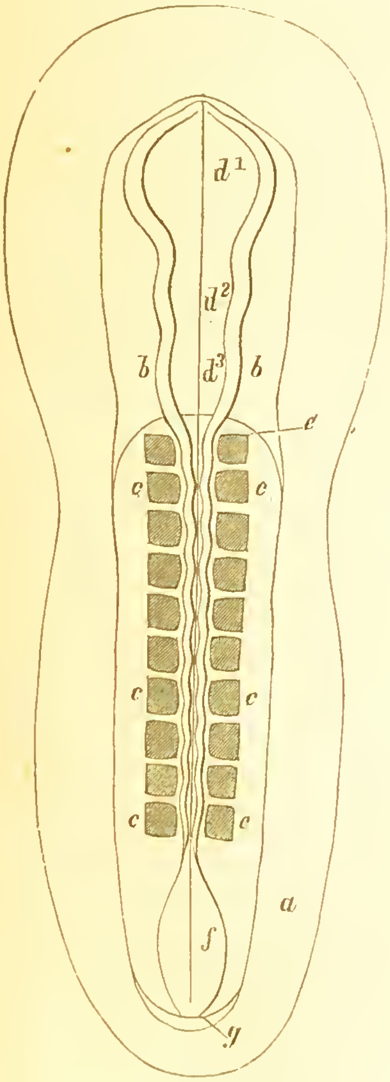

Fig. XXXVI.—Magnified view of the area pellucida of the vitellus, fig. XXXI. —*b*, *b*, crests of the dorsal laminæ, receding from each other. anteriorly to form the cerebral cells; d^1, cell of the eyes and thalami; d^2, cell of the corpora quadrigemina; d^3, cell of the medulla oblongata; *c*, *c*, *c*, *c*, laminæ dorsales, of which ten are present on either side; *e*, anterior fold of the blastoderma, from which the involucrum capitis is formed, shining through; *g*, posterior fold of the blastoderma, still very narrow, from which is formed the involucrum caudæ; *f*, chorda dorsalis.

creseentic in the first instanee also (fig. XXXVI. *g*), the future *involucrum caudæ;* the sides now begin to turn inwards also, by which the transparent germinal area is drawn in and bent laterally, and made to assume a eomplete fiddle shape. (figs. XXXV. and XXXVI.) The embryo is three lines in length; the broader and more strongly bent extremity, with its transverse plait or envelope, is visible to the naked eye. The eristæ of the dorsal laminæ have become approximated through a larger spaee, toueh each other (fig. XXXVI. *b*, *b*,) and finally eoaleseing eompletely, close the canal for the spinal cord (fig. XXXVII. *A*, *g*), beneath whieh the more delieate ehorda dorsalis with its sheath (*e*), extends. The four-eornered laminæ, the future vertebral arches, have increased in number, new ones springing up in front and behind; and, about the thirty-sixth hour, as many as from ten to twelve pairs may be reckoned (fig. XXXVI. *c*, *c*, *c*, *c*). At this time the dorsal laminæ separate still more from one another in front, so that many spaees or cells become distinetly visible between them; the largest, or most anterior of these eells (fig. XXXVI. d^1) has beeome somewhat pointed forwards, and curved underneath; laterally it presents wide bending inlets, which indieate the first formation of the eyes; it is the cell of the thalami and crura of the eerebrum; the seeond smaller cell (d^2), is the eell of the corpora quadrigemina; the third, an elongated cell (d^3) belongs to the medulla oblongata. The transparent mass of the brain and spinal marrow aequires greater eonsisteney, and is covered with a firmer, but highly transparent layer, the future membranous involucra of the nervous centres; the brain, and medulla oblongata, up to this time, are, therefore, in faet, shut vesicles, which, on account of their transparency only, appear as

Fig. XXXVII.

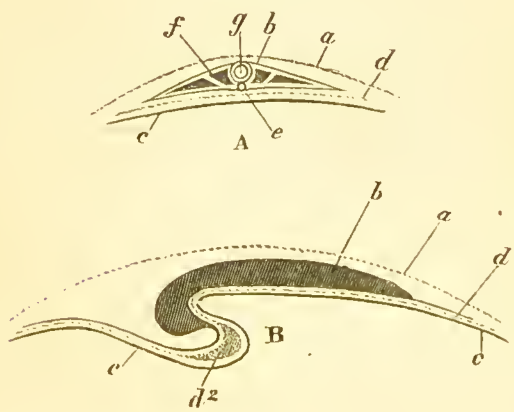

Fig. XXXVII.—Ideal sections of the embryo of fig. XXXII; letters of reference as in fig XXXI. *A* Over the chorda dorsalis, *e*, is seen *g*, the canal for the spinal cord, formed by the union of the cristæ of the dorsal laminæ. *B*, longitudinal section. The heart, d^2, is evolved as a thickening of the lamina vasculosa.

open spaces lying between the sinuous cristæ of the dorsal laminæ. Outwardly, from the cristæ of the dorsal laminæ, and the four-cornered laminæ of the vertebral arches, proceeds the serous lamina of the germinal membrane, thickening as it grows, and bending from both sides at the same time slightly inwards ; in this part a number of small dark folioli or leaflets, make their appearance simultaneously, which become particularly plain in the transverse section (fig. XXXVII. *A*, and especially fig. XL. *A*, b^2) ; these are the rudiments of the transverse processes of the vertebræ, and, farther out, of the ribs likewise ; these lateral prolongations of the serous lamina are called the *laminæ ventrales*, ventral laminæ (*fasciæ abdominales*, Wolff, *laminæ viscerales s. abdominales* of others.) As the dorsal laminæ arise more perpendicularly in plaits, and converge to close the spinal canal, so the ventral laminæ spread more in breadth, bend in inferiorly, and converge to form the lateral parietes of the abdomen, and finally to close this cavity. The vascular and mucous layers follow the turnings and general course of the serous layer, and decline anteriorly under the head of the embryo, by which the *fovea cardiaca* of Wolff, the anterior depression which marks the commencement of the intestinal canal, becomes deeper (fig. XXXIV. *B*, *f*, and XXXVII. *B*). From this sinus the vascular and mucous layers turn more posteriorly, and immediately again proceed forwards, to be continued in the plane of the germinal membrane (fig. XXXVII. *B*, where the heart, d^2, is indicated). This part of the germinal membrane, then, covers the head of the embryo when it is viewed from below, and on this account is called the *involucrum capitis*—the cranial envelope or cap—among writers on development; it is not any independent formation.

Whilst these changes in the form of the serous layer are going on, others are proceeding, pari passu, in the vascular lamina, in the following order, from the end of the first day to the middle of the second. The *area vasculosa* (figs. XXXII. and XXXV. *c*) has enlarged, and from a form rather elongated, has assumed one that is rounder. Its outer circumference is beset with darker aggregated-looking masses (fig. XXXV.) ; single isolated points appear, and between these clefts are formed, that by-and-by run together and form channels which unite in meshes with one another; in these channels a clear colourless or extremely pale yellow fluid can by-and-by be distinguished in motion—this is the blood. The halones (fig. XXXII.), which had become more sinuous towards the beginning of the second day, now vanish entirely. Along with

these occurrences in the periphery of the vascular lamina, the *development of the heart* has been advancing in the centre, under the transparent germinal area and the serous layer of the embryo. The vascular lamina becomes thicker, and appears darker in this point; the heart shows itself as a somewhat sinuous sac, interposed between and pushing apart the mucous and serous laminæ (fig. XXXVII. *B*, d^2). As the development advances, the heart is observed from the under or abdominal aspect of the

Fig. XXXVIII.

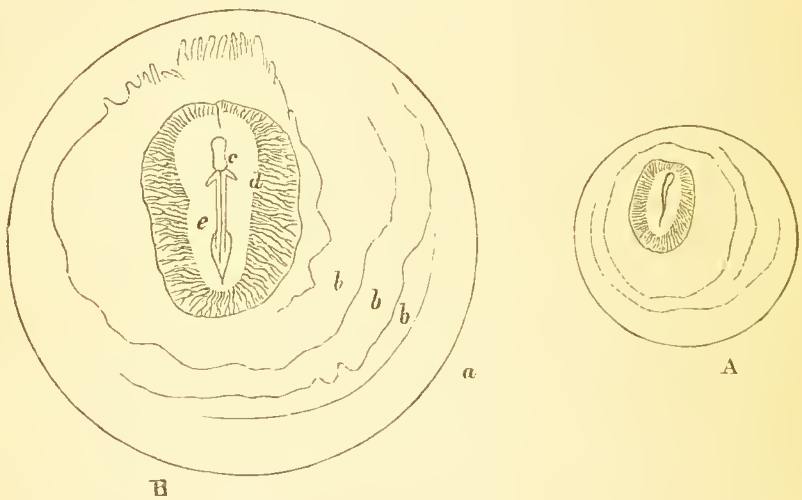

Fig. XXXVIII.—An incubated vitellus of the Jackdaw's egg; *A*, of the natural size; *B*, magnified—*a*, vitellary membrane; *b*, *b*, *b*, halones; *c*, embryo; *d*, area pellucida; *e*, area vasculosa. (Compare with figs. XXXII. and XXXV.)

Fig. XXXIX.

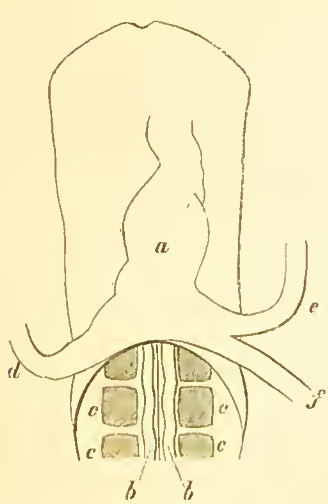

Fig. XXXIX.—Anterior end of an embryo scarcely of greater age than that of fig. XXXII. seen from the abdominal (the vitellary) aspect, to show the first formation of the sacculate heart, *a*, with its immerging vascular (venous) trunks, *d*, *e*, *f*; *b*, *b*, crests of the laminæ dorsales seen shining through.

embryo as a sac, simple and undefined anteriorly, of greater breadth posteriorly, and terminating in two (fig. XXXIX. *d*, *f*) or three (fig. XXXIX. *e*) crura; these are the future great *venous trunks*, which as yet are lost insensibly in the germinal membrane. Even at this period undulating motions, rhythmical contractions of the heart may be perceived, by which the somewhat wavy appearance of the organ is produced; the same clear, or nearly colourless fluid is in motion in the heart as in the vessels in the periphery. The heart occupies the whole space from the involucral point of the germinal membrane to the cranial end of the embryo, and is consequently, when the embryo is contemplated from below, covered by the part of the serous membrane which at the same time forms the involucrum capitis. The embryo, which at the end of the first day bore some resemblance to a punt or flat-bottomed boat, by the middle of the second day has acquired the form of an ordinary small boat turned over, the sides of which (the ventral laminæ) converge, whilst the head is much curved or beak-fashioned (the bending down of the head), and furnished with a particular cover (the involucrum capitis); the posterior part is also somewhat recurved, but much less so than the anterior part, by the commencing development of the caudal envelope. The ventral channel extends from the posterior margin of the heart (fig. XXXIX.) to the crescentic plait of the caudal envelope (fig. XXXVI. from *c* to *g*, seen through the back of the embryo [118]).

[118] The study of these metamorphoses of the first half of the second day is attended with extraordinary difficulties, particularly as regards the first appearance of the vascular system. On the structural changes of the vascular lamina, the formation of the globules of the blood, &c. see Chapter III. in which the several histological metamorphoses are described. [This fundamental idea of the formation of the embryo mediately from a blastoderma, dividing into two laminæ, called serous and mucous, having relation severally, the first to the animal, the second to the vegetative system, has just been called in question by Reichert, in a work of the very highest interest, entitled *Das Entwickelungsleben im Wirbelthierreich*, (*Formative-life in the Vertebrate-Animal-Kingdom*) 4to. Berlin, 1840, which may be regarded as another of the fruits of the discovery of Schleiden and Schwann, of the origin from cells, and mode of elementary formation of organized beings generally. Reichert starts with the principle that the yolk is to be regarded in some sort as the *embryo in a state of solution*, and that the process of evolution does not necessarily take place through the medium of what is called a germinal membrane divided into strata, but immediately from the vitelline matter itself. His researches lead him to conclude that the evolution of the vitellus into the embryo of the vertebrate animal, proceeds according to one of two principles: in the first, which obtains among fishes and the naked amphibia, the central organs of the animal life,—the central nervous and

§ 53. The changes that occur during the second half of the second day, from the thirty-sixth to the fiftieth hour, are the following: the dorsal laminæ are closed along the whole line of their course; the head curves itself more and more under the body, so also does the tail; and the involucra both of the head and tail again bend towards the dorsal aspect; the ocular sinuses are separated more distinctly from the anterior cerebral cell, which now lies completely underneath; the cell of the corpora quadrigemina is much enlarged; from the cell of the medulla oblongata the organ of hearing arises as a vesicular eminence, and in its anterior part, a particular contraction for the cerebellum is very commonly to be perceived; the spinal cord is now a laterally compressed tube. The blood collects in the periphery of the vascular lamina within a circular sinus or annular vessel, the future *sinus s. vena terminalis.* The heart soon parts the ventral laminæ from one another, like a wedge, and so forms a hernia behind the point of reflection of the germinal membrane to the cranial involucrum; it is here that the venous trunks penetrate which carry the blood from the periphery of the vascular lamina to the heart. The heart itself has now become a relatively narrower, and more curved or spirally twisted sac, which contracts with greater vigour than heretofore. The anterior extremity of the heart divides into two crura, which proceed to the cover of the future oral cavity, and run for a certain way under the vertebral column, where they blend into the future aorta, separate again, and give off two great transverse branches, which lose themselves in the germinal membrane towards the periphery of the vascular area. The blood by degrees

mucous systems, as also the allied assisting systems and organs (the skin, the vertebræ, the blood) are severally produced, without intermedium from the vitellus; in the second, which obtains universally among the higher vertebrata, the scaly amphibia, birds, mammalia and man, the immediate evolution of the embryo from the yolk takes place only in reference to the central systems; the part which he names *membrana intermedia* (area vasculosa, formation of the blood) now becomes the mediate instrument by which the further evolution of the embryo from the yolk is carried on. The ovum of the frog (*Rana esculenta* and *R. temporaria,* afforded the ova employed by Reichert) is the best subject for observing the genesis of the embryo immediately from the vitelline matter.—R. W.]

acquires a red colour. The transparent germinal area continues fiddle shaped. In the periphery the serous lamina recedes still more from the other laminæ of the germinal membrane that lie under it, at the same time that it is raised round the whole circumference into a fold which grows with great rapidity in the beginning of the third day (fig. XL. *A*, *B*, *f*). The whole embryo is still more bent on itself; the cell of the corpora quadrigemina forms its anterior and superior end; the caudal end is turned in more than ever, and the mucous layer following the bending, a depression is here formed in the same way as we have seen one produced towards the anterior extremity, at the fovea cardiaca; the digestive cavity is now a channel of considerable depth; which, however, is still largely patulous towards the vitellus, from which undoubtedly it derives formative materials.

§ 54. *Second period of the Development of the Chick, to the evolution of the second circulation.*

The second period in the history of the development of the chick begins with the third day, in the course of which the circula-

Fig. XL.

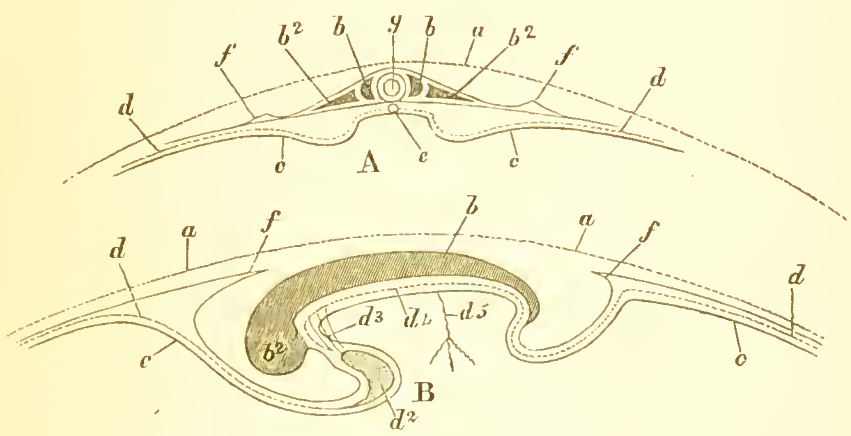

Fig. XL.—Ideal section of an embryo somewhat younger than that of Fig. XLI. *A*, transverse section; *a*, vitelline membrane; *b*, *b*, laminæ dorsales et vertebrales; b^2, b^2, laminæ abdominales and transverse processes; *c*, *c*, lamina mucosa, which is seen bending round under the chorda dorsalis (*e*), to form the intestinal canal; *d*, *d*, lamina vasculosa; *f*, *f*, peripheral portion of the lamina serosa, proceeding to form the lateral involucra and the amnion; *g*, medulla spinalis.—*B*, longitudinal section; *a*, vitellary membrane; *b*, lamina serosa, and dorsum of the embryo; b^2, head of the embryo; *c*, *c*, lamina mucosa; *d*, lamina vasculosa; d^2, heart; d^3, branchial arteries; d^4, aorta; d^5, artery of the blastoderma (*arteria vitellina*).

tion in the vitelline vessels is completely established (figs. XLI. and XLVIII.), and embraces farther the changes that take place during the fourth and fifth days, till the allantois has appeared, the membrane of the shell has been attained, and the second circulation is established; the first, which had reached its highest development at the end of the fourth day, now beginning to suffer an arrest, and to decline in extent and activity (figs. XLIII. and XLVII.). In the course of this period the embryo is completely detached from the germinal membrane, and becomes enveloped in peripheral productions of the same part. The third day is the most remarkable in the whole history of the development, as, from the general vigour of the formative processes, all the organs now begin to be evolved, and the characteristic form of the embryo to be more particularly declared. We shall speak of the different appearances in groups, as they are associated with the several laminæ of the germinal membrane, tracing each principal formation, and each individual organ in its progress from the beginning to the end of the period we are now considering [119].

§ 55. The dorsal laminæ have increased in size, and the rudiments of the vertebræ within them (the vertebral laminæ) are growing both anteriorly and posteriorly (fig. XLI. *h*, *h*); they surround the spinal canal on the sides, are also to be seen over the medulla oblongata, and several even exist anterior to the ear (fig. XLII. at *d*) [120]. In the vicinity of the chorda dorsalis, outwardly, between it and the vertebral laminæ, arise the first cartilaginous rudiments of the bodies of the vertebræ, which blend superiorly with the laminæ of the vertebral arches, close in the canal of the spinal marrow below, and surround the cartilaginous column

[119] It may be as well to observe in this place, that the assumption of determinate periods and days has always something arbitrary in it, inasmuch as different eggs advance in their development with very different degrees of rapidity, even when they are kept together in a perfectly equable temperature. Neither do the individual organs always bear the same precise relations to one another in the degrees of their development at the same particular moment: one often appears to lag a little behind another. [The idea of the embryo becoming *pinched off* from the blastoderma, is combated by Reichert (l. c. p. 110).—"The embryo," says he, "does not detach itself from a germinal membrane that to the senses has no existence; neither does it part from the yolk, from which it is to receive development. The supposed pinching off depends much rather on the canalicular formation of the inferior visceral tube and the intestinal system which it includes." —R. W.]

[120] It is usual at this time to observe two pairs of vertebræ lying over the auditory vesicle, as in fig. XLII. *d*.

(sheath) of the chorda dorsalis. Towards the fifth day the chorda dorsalis begins to disappear. The spinal marrow is laterally compressed, and falls into two halves, each of which is again divided into an upper and an under fasciculus. It is on the fifth day that the rudimentary enlargements or processes indicative of the position of the future *extremities*, make their appearance; the earliest traces of the cerebral envelopes were already con-

Fig. XLI.

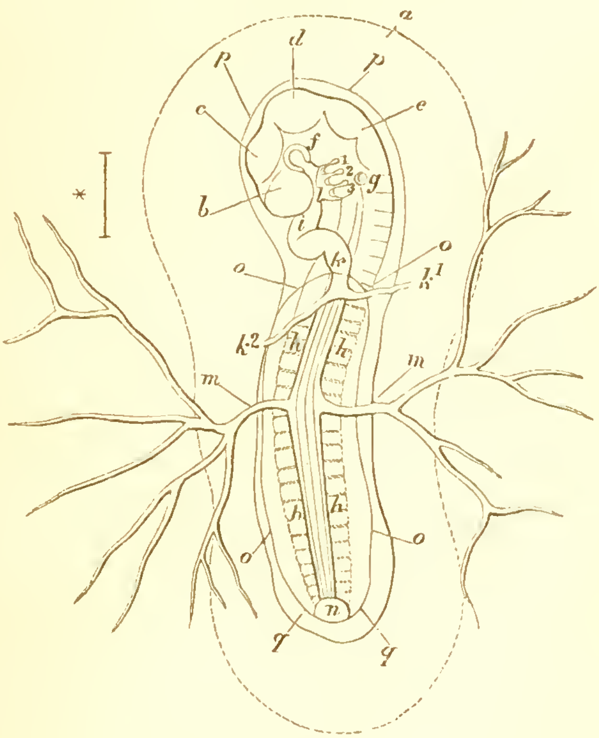

Fig. XLI.—View of an embryo, four lines long, magnified about eight diameters. The embryo is seen from the abdominal surface; the time is the middle of the third day.—*a*, Area pellucida; *b*, anterior cerebral cell (the hemispheres); *c*, cell of the thalami and crura cerebri; *d*, corpora quadrigemina; *e*, cerebellum and medulla oblongata; *f*, the eye, a wide cleft inferiorly; *g*, the auditory vesicle lying in front of the medulla oblongata; *h*, *h*, *h*, vertebral lamina; *i*, ventricle of the heart; *k*, atrium cordis; k^1, superior, and k^2, inferior vein of the blastoderma; *l*, bulb of the aorta, giving off the four branchial arteries, over which lie three branchial arches, 1, 2, 3; *m*, *m*, arteries of the blastoderma proceeding from the divided trunk of the aorta; inwards from either aorta the bodies of the vertebral laminæ are united by suture; *n*, the Allantois just budding forth; *o*, *o*, *o*, *o*, margins of the abdominal cavity, reflected superiorly into the involucrum capitis, *p*; inferiorly into the involucrum caudæ, *q*, *q*. The mesentery, Wolffian bodies, &c. which have by this time begun to appear, are left out. The actual length of the embryo is indicated by the line with the asterisk.

spicuous on the fourth day. The medulla oblongata (fig. XLII. between *c* and *d*) is extremely flat above, in consequence of the divergence of the superior fasciculi from one another, and thus is the basis laid of the fourth ventricle, which appears to be covered with its own peculiar medullary and enveloping lamina [121]. Anteriorly, the fasciculi of the medulla oblongata ascend towards the corpora quadrigemina in two perpendicular laminæ, which, on the fifth day, become applied to one another, and so cover the fourth ventricle superiorly and anteriorly; thus is the *cerebellum* produced, visible from the side as an enlargement (fig. XLI. *e*, fig. XLII. *d*, figs. XLIII. and XLVII. a^2), behind which the fourth ventricle presents itself as a deep depression (fig. XLIII. and XLVII. *d*). The *corpora quadrigemina* form a simple and very considerable cell, which projects forwards in an arched or vaulted manner, but, with the increasing declension of the head, turns always more and more downwards (fig. XLI. and XLIX. *d*, fig. XLII. *e*, figs. XLIII. and XLVII. *a*, fig. XLV. *B*, *a*, fig. XLIV. *b*, fig. XLVI. *c*). The laminæ, which form the cerebellum, proceed upwards, blending in the corpora quadrigemina, under which the fourth ventricle is continued as the aqueductus. Anteriorly to the corpora quadrigemina lies the asymmetrical, smaller, middle cerebral cell (figs. XLI. and XLVII. *c*, figs. XLII. and XLIII. *f*, fig. XLV. *B* before *r*), formed by the advancing laminæ of the medulla oblongata as the *crura cerebri;* it is open superiorly, and extends, as the third ventricle, with a wide opening into the infun-

[121] The investigation of this point is difficult, and I have not been able fully to satisfy myself that the fourth ventricle is covered with an enveloping layer; the outer coverings over this part are thick, and obscure the view of what lies under them

Fig. XLII.

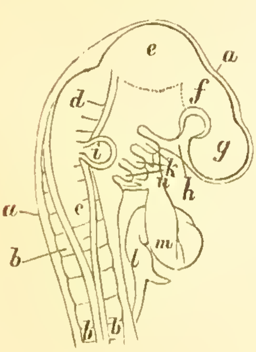

Fig. XLII.—Anterior end of an embryo somewhat more highly magnified and a few hours older than that of fig. XLI. *a*, *a*, Cranial involucrum; *b*, *b*, vertebral laminæ near the crests of the now closed dorsal laminæ; *c*, spinal cord passing into the medulla oblongata *d*, which in its turn passes by a depression (the fourth ventricle) into the corpora quadrigemina *e*; *f*, mesocephalon (thalami and crura cerebri); *g*, hemispheres; *h*, superior maxillary bone; *i*, auditory vesicle; *k*, branchial arches; *l*, atrium cordis; *m*, the heart hanging forwards; *n*, bulb of the aorta.

dibulum, which on the second day was directed straight downwards, but which now, from the great bending in of the head, is turned backwards, and even upwards. In this cell, which was the first formed, and foremost cerebral cell (fig. XXII. d^1), the *thalami* make their appearance towards the end of the period. The most anterior cerebral cell at the present epoch is symmetrical, and contains the hemispheres (figs. XLI. XLII. XLIII. and XLVII. *b*, fig. XLII. *g*, fig. XLVI. *d*, fig. XLV. *B*, *p*); according to the natural curvature of the embryo, it lies completely downwards. The *optic nerve* appears as a vesicle betwixt the middle and anterior cerebral cell, in which the external envelopes (the outer portion of the serous membrane), preparatory to the formation of the *eye ball*, bend circularly inwards in the shape of a sac, and externally form a projection, which opens downwards as a cleft; this is closed by degrees, and at length forms a colourless thin streak, whilst the rest of the bulb, from the deposition of the pigmentum nigrum, is dark or deeply coloured; the *lens* makes its appearance very early (on the third day), forming a particular closed capsule within the sac of the external envelopes (the ball of the eye), and lying in the midst of an albuminous ball, the *vitreous humour*. (On the meta-

[122] The development of the eye is among the most difficult points in the whole subject; much remains to be done in it. The labours of Huschke upon the point are admirable. Vide Meckel's *Archiv für* 1832, S. 1. tab. i, and Ammon's *Zeitschrift für Ophthalmologie*, B. IV. S. 272, tab. ii.

FIG. XLIII.

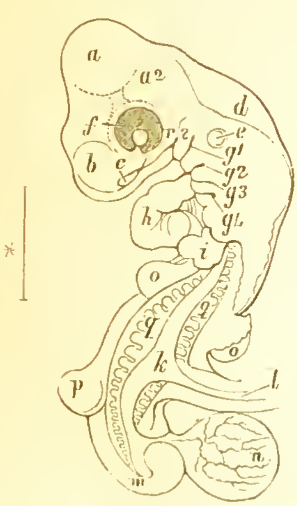

Fig. XLIII.—Embryo of the fowl, nearly five lines in length, at the seventy-second hour of incubation (transition from the third to the fourth day). The abdominal surface is partly laid open and the parts separated; the amnion is removed. *a*, Corpora quadrigemina; *b*, the hemispheres; *c*, the nasal depression; *d*, the fourth ventricle, in front of which lies the cerebellum a^2, which is now more distinctly defined; *e*, the ear; *f*, the eye, in the choroid of which, already furnished with its pigment, a cleft is seen; g^1—g^4, the four branchial clefts; *h*, the heart; *i*, the liver; *k*, the intestinal canal, with its open vitellary duct *l*; *m*, the rectum still ending in a blind sac; *n*, the allantois; *o*, the anterior, and *p*, the posterior, extremity; *q*, *q*, *q*, *q*, Wolffian bodies; *r*, upper jaw; *s*, under jaw.

morphosis of the eye, consult figs. from XLI. to XLII). The *organ of hearing*, at first a simple vesicle arising from the medulla oblongata, soon becomes a distinct sac, which, examined from behind, appears attached to the medulla oblongata by means of a pedicle,—the *acoustic nerve* (fig. XLII. *i*); distinct from it a cleft appears (fig. XLIV. *A*, *f*), which increases over against the acoustic sac, and sinking into it, forms the external *meatus auditorius*. If the embryo be lying upon its side, the acoustic sac, which subsequently forms the labyrinth, is seen as a rounded enlargement (fig. XLI. *g*, XLIII. *e*, XLIV. *A*, *n*), which in the course of the period under consideration comes continually forward. About the

FIG. XLIV.

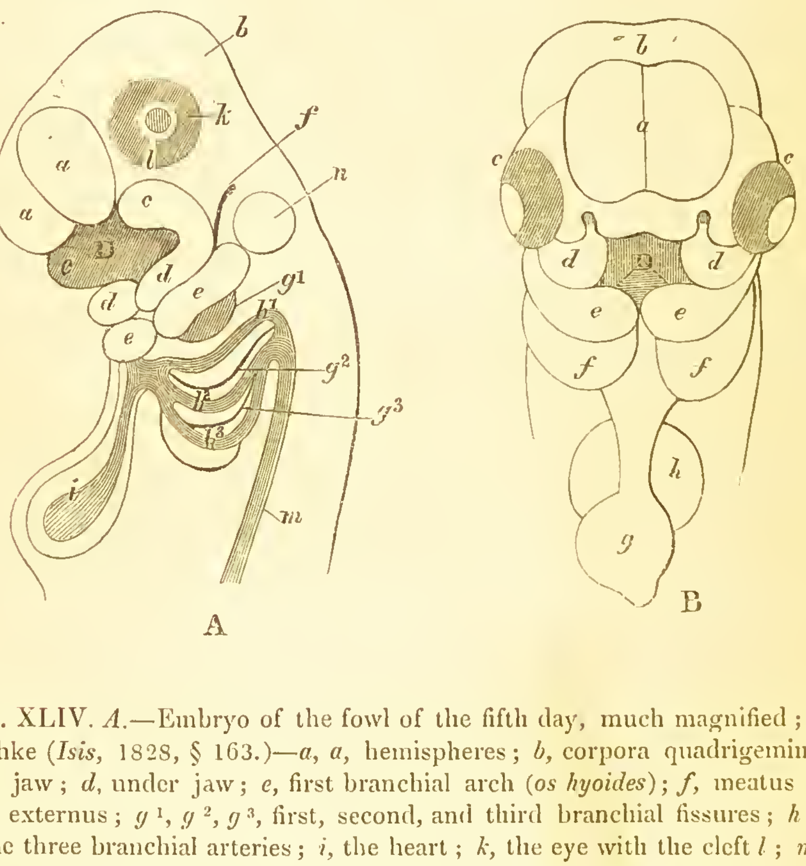

Fig. XLIV. *A*.—Embryo of the fowl of the fifth day, much magnified; after Huschke (*Isis*, 1828, § 163.)—*a*, *a*, hemispheres; *b*, corpora quadrigemina; *c*, upper jaw; *d*, under jaw; *e*, first branchial arch (*os hyoides*); *f*, meatus auditorius externus; g^1, g^2, g^3, first, second, and third branchial fissures; h^1, h^2, h^3, the three branchial arteries; *i*, the heart; *k*, the eye with the cleft *l*; *m*, descending aorta; *D*, cavity of the mouth and fauces; *n*, acoustic pouch.

Fig. XLIV. *B* (after Huschke), front view of the embryo of the fowl, of the fourth day: *a*, hemispheres; *b*, corpora quadrigemina; *c*, eye; *d*, upper jaw; *e*, lower jaw; *f*, enlargement of the os hyoides; *g*, ventricle of the heart; *h*, atrium cordis; *D*, oral aperture and faucial cavity.

beginning of the third day, the *olfactory nerve* shows itself towards the basis of the cell of the hemispheres; at a later period the *nasal hollow* (fig. XLIII. *c*) is observed as a broad depression with puffed edges; on the fifth day both nasal hollows have become deeper, and are now distinct from one another.

§ 56. Very important metamorphoses go on during this period in the ventral laminæ lying on either side of the dorsal laminæ, or middle portion of the embryo; so far these ventral laminæ are formed from the serous layer of the germinal membrane only; they separate into a superficial thinner layer (figs. XL. and XLV. *A*, b^2 and *f*), which, like a cuticle, loses itself in the peri-

Fig. XLV.

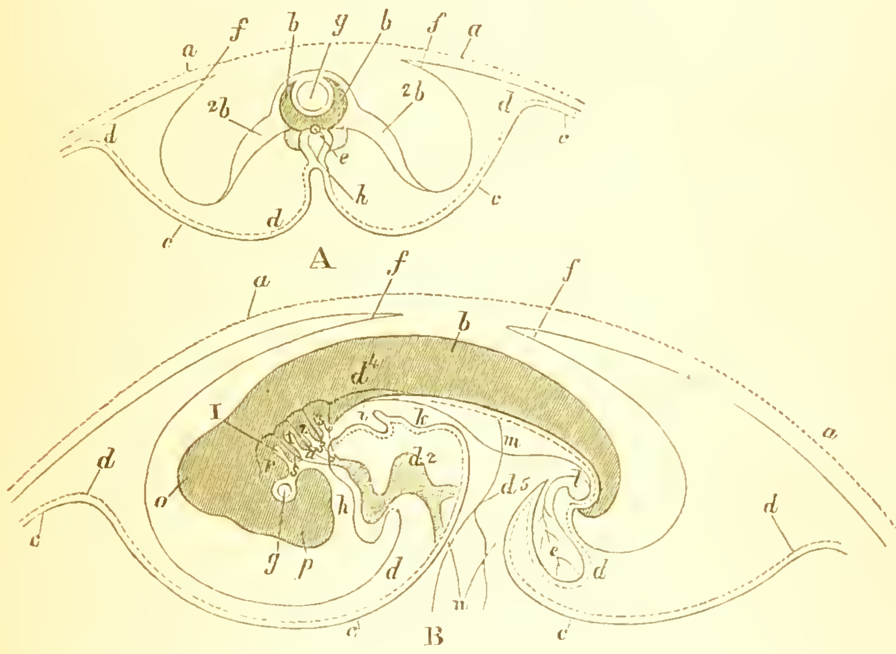

Fig. XLV.—Ideal section of an embryo nearly at the end of the third day :— *A*, transverse section; *a*, vitelline membrane, *b*, *b*, laminæ dorsales, &c. as in fig. XL. *B*, longitudinal section. The cranial and caudal involucra approximate, and at length meeting, they close the amnion; *g*, the eye; *h*, entrance into the mouth, or fovea cardiaca; *i*, the œsophagus, with the rudimentary lung budding out as a diverticulum from it; *k*, expansion of the alimentary tract, marking the seat of the stomach; *l*, posterior shut extremity of the intestine, from which proceeds the allantois *e*, surrounded by the vascular lamina *d*; *m*, the mesenteric lamina; *n*, passage from the vitellus to the open abdomen; *o*, anterior part of the head (corpora quadrigemina); *p*, hemispheres; *r*, superior maxilla; *s*, inferior maxilla; *I*, oral cleft or aperture; 1, 2, 3, three branchial clefts. Other references as in fig. XL.

phery of the embryo upon the deeper stratum; and, as it has already suffered a reflection anteriorly opposite the heart, and formed the involucrum capitis; so, towards the posterior part, it has bent over as the involucrum caudæ, and been formed into plaits or folds laterally, as the lateral envelopes. Thus is the serous layer of the germinal membrane, or upper layer of the ventral laminæ, raised on every side to converge into an elliptical plait towards the back of the embryo; on the fourth day, these plaits have approached each other very closely; the anterior is now called the *vagina capitis* (fig. LXV. *B, f,* forwards); the posterior *vagina caudæ* (fig. XLV. *B, f,* backwards); the lateral folds may, in like manner, be entitled the *vaginæ laterales* (fig. XLV. *A, f, f*); they coalesce at the end of the fourth day, and form a visible cicatrice over the lumbar region of the embryo. In this way we have a complete vesicular envelope thrown around the embryo,— the AMNION, (fig. XLVI. *a, a,*) which is filled with fluid. The

Fig. XLVI.

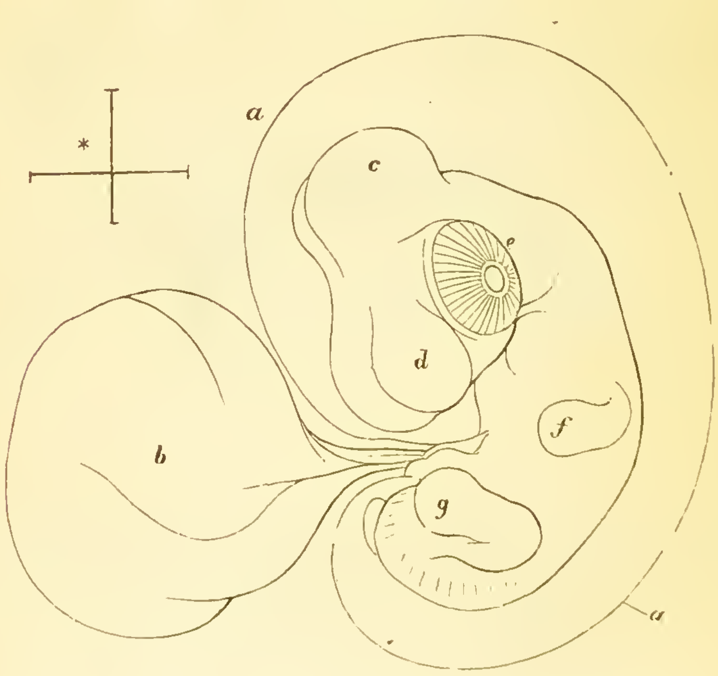

Fig. XLVI.—Outline of the embryo of the fowl, at the end of the fifth day, much magnified; *a, a,* amnion; *b,* allantois; *c,* corpora quadrigemina; *d,* hemispheres; *e,* eye; *f,* anterior, and *g,* posterior extremity. The natural dimensions of this, as of many of the other figures, are indicated by a line or lines with an asterisk.

upper layer of the fold (fig. XLV. *A* and *B*, lying under the vitelline membrane, *a*,) covers the whole germinal membrane, and grows around the yolk as a serous capsule or cyst, *vesica serosa*—the false amnion of Pander. At the place where the embryo lies, this layer is separated from the rest of the germinal membrane by a considerable space. The inferior layer of the serous ventral lamina forms the ventral paries, and gives origin to the bones and muscles which compose the neck and trunk. Inferiorly, the vascular lamina lies upon it, and this, with the serous lamina, evolves the formations which are now to be described. On either side, under the vertebral column, there is a lamina detached, which grows thicker, and increases in a direction perpendicularly downwards; these are the *laminæ mesentericæ*, between which there is, at first, an open triangular-shaped channel or cleft, the *foramen mesenterii* (erroneously regarded by Wolff as an intestinal channel); both the mesenteric laminæ push the mucous layer before them, and speedily unite, at an acute angle, in the suture—*sutura* (fig. XLV. *A*, *h*, *B*, *m*). The furrow or foramen of the mesentery resembles an equilateral triangle, with one of its angles pointing directly downwards. After the union of the two mesenteric laminæ, the resulting structure grows most rapidly posteriorly, opposite the middle of the body, and here forms a septum, dividing the abdominal cavity into two halves.

It is at the beginning of the intestinal canal, where the ventral laminæ are converging, that the *branchial arches* are developed; the parietes of the body here become thinner; and in this, the cervical region, several clefts or fissures make their appearance, which sink downwards, and penetrate through the mucous layer; there are three pairs, or, with the oral aperture, four pairs of such fissures, but the posterior pair are extremely small; they are called the *branchial fissures*—fissuræ branchiales ([123]); between

[123] The discovery and true interpretation of the branchial fissures in the embryo of the higher vertebrata, belongs to Rathke, *Isis*, 1825, vol. i.; *Nova Acta Acad. Natur. Curiosor.* xiv. Shortly after this, Huschke illustrated the matter, particularly in the chick, *Isis*, 1826 and 1827. Very recently Reichert has pursued the subject deeply; he calls the branchial arches *visceral arches*—Müller's *Archiv für* 1837. His assertion, that these are not *branchial* arches, is a mere dispute about a word; it was never imagined that the parts in question were proper *gills*; but they are vascular arches, which are in every respect analogous to the vascular arches of the gills of fishes, only not branching like these.

them lie three segments or divisions of the ventral laminæ, which are blunt and rounded anteriorly, bevelled off towards the digestive cavity, and therefore sickle-shaped; these are named the branchial arches—*arcus branchiales* (figs. XLI. XLII. XLIII. XLV. &c.); the fourth branchial arch is placed hindmost, and is not yet distinct from the ventral lamina. On the fourth day, the two most anterior branchial arches increase in thickness (fig. XLIII. between g^1 and g^2); a new fissure is formed posteriorly (fig. XLVII. g^4); on the fifth day, the foremost fissure closes (fig. XLIV. *A*, between *d* and *e*), and the foremost branchial arch unites with its fellow of the opposite side, and forms the *lower jaw* (fig. XLIV. *A, d, B, e*); the next in succession is transformed into the *os hyoides* (fig. XLIV. *A, e, B, f*). The two last branchial fissures close up on the fifth day; at the same time, the first is lost entirely; but the second continues longer open (fig. XLIV. *A*, g^1)[124]. On the third and fourth days, the part of the ventral lamina, which is situated in front of the lower jaw, thickens and resolves itself into the *upper jaw* (fig. XLIII. *s*, and XLVII. 1, above 2); this part is more strongly marked on the fifth day (XLIV. *A, c*). The two sides of the upper jaw do not meet in

[124] The first branchial fissure is metamorphosed internally into the Eustachian tube, externally into the external meatus (fig. XLIV. *A, f*). I have, I may state, found that the order in which the branchial fissures disappear is far from being quite regular; the whole of them may, in many cases, be found existing more or less simultaneously (fig. XLVII. &c.).

Fig. XLVII.

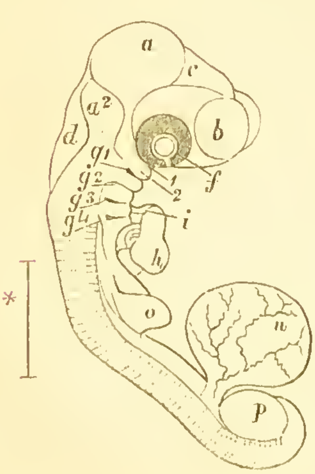

Fig. XLVII.—Embryo of the fowl of the first half of the fourth day; *a*, corpora quadrigemina; *b*, hemispheres; *c*, mesocephalon (thalami); *d*, fourth ventricle; *f*, eye, the cleft in the choroid beginning to close; g^1, g^2, the first and second branchial spaces still entirely open; g^3, g^4, the third and fourth spaces open behind only; *h*, the ventricle of the heart, now of a rounded form; *i*, aorta; *n*, allantois; *o*, anterior, and *p*, posterior extremity. 1, 2, upper and under jaw. The line with the asterisk indicates the natural length of the embryo.

the first instance; they coalesce at a later period, through the medium of the frontal process, which is developed betwixt the eyes (fig. XLIV. *B*, over *D*.)

The rudiments of the *ribs* begin to be formed in the parts of the ventral laminæ which lie behind the branchial arches; the extremities show themselves upon the external aspects of the same laminæ. Of the *extremities* there is still no trace to be discovered in the first half of the third day (fig. XLI.), but in the second half of that day they arise on the sides of the ventral laminæ as narrow edgings, which by the close of the day have turned more upwards, gained the outer margins of the ventral laminæ, and changed into rounded offsets (fig. XLIII. *o*, *p*), the posterior pair being distinguished from the anterior by somewhat greater breadth (fig. XLVII. *o*, *p*), on the fifth day they recede still more upwards towards the dorsal laminæ, become pediculated, and present a broad shovel-shaped termination (fig. XLVI. *f*, *g*).

§ 57. The *vascular lamina* in its development follows the phases of the first, or vitellicular circulation, which, as has been

Fig. XLVIII.

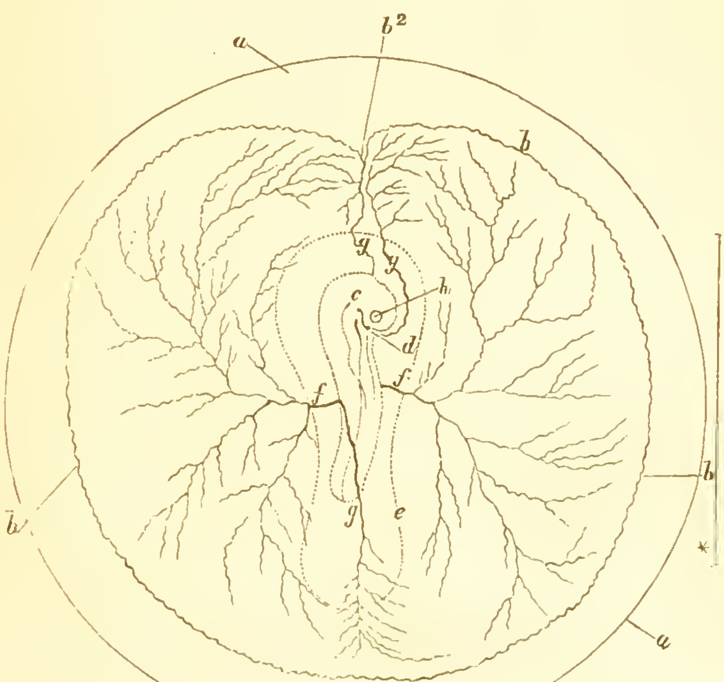

Fig. XLVIII.—View of the Vitellus, magnified rather more than two diameters, exhibiting the circulation of the blastoderma completely developed:—*a*, Vitellus; *b*, vena s. sinus terminalis; b^2 point of approximation to the embryo

stated, attains its height on the fourth day (fig. XLVIII.). Immediately under the head of the embryo, three blood-red bounding points are seen (fig. XLVIII. *d*), the expression of the alternating eontraetions of the three divisions of the heart, whieh are now in the eourse of formation,—the *sinus venosus* (fig. XLI. *k*, XLII. *l*), whieh reeeives the veins, and towards the end of the third day shows traees of the two aurieles, the *ventricle* (XLI. *i*, XLII. *m*), and the *bulbus aortæ* (XLI. *l*, XLII. *n*), divided from the ventriele by a eontraetion. In this period the heart presents sueh diversities that it may be said to be in a state of eeaseless metamorphosis, both as regards form and position. On the seeond day, it is a somewhat spirally twisted eanal lying under the brain (fig. XLI. *i*); on the third day, it has drawn itself more baekwards, beeome more eoneentrated, and bent round as it were into a kind of loop (fig. XLII. *m*), when it appears to projeet in the form of a tumour between the ventral laminæ (figs. XLII. and XLIII. *h*), first inelining to the left and then to the right, and being all the while within the eompass of the involuerum eapitis (fig. XLIX. *f*). The ventriele, whieh during the third day is still eanalieular, beeomes more globular on the fourth day (fig. XLVII. *h*), and pointed underneath, so that it acquires the proper heart-shape (fig. XLIV. *B*, *g*); it then lies very mueh to the right, whilst the sinus venosus, whieh is beeome more distinet from it, lies more to the left (fig. XLVII. behind *h*). At the end of the third day, the eonstrietion between the ventriele and aortal bulb (the fretum of Haller), is already well marked (fig. XLII. *n*). On the fourth day, the museular mass of the heart and the septum ventrieulorum is produeed; in the sinus venosus the septum is not begun to be formed till the fifth day, and the two apiees into whieh the veins even on the third day were seen to plunge (fig. XLII. below *l*), enlarge, and beeome the aurieles. Some time before the bulbus aortæ beeomes distinetly pinehed off (fig. XLIX.), it divides at the beginning of the third day into four pairs of vascular arehes, whieh show themselves through the abdominal laminæ, the most posterior of the four

of the terminal sinus, and its communication with the veins *g*, *g*; *c*, aorta; *d*, punctum saliens, or pulsating point of the heart; *f*, *f*, arteries of the blastoderma; *g*, *g*, veins of the same (one inferior, two superior; sometimes there is but one above as well as below); *e*, *e*, the fiddle or guitar-shaped area pellucida; *h*, the eye. (This figure will be found to correspond in almost every particular with that of Pander, tab. iv. fig. 1. of his well-known work, *Entwickelungsgeschichte des Hühnchens im Eie*). The more delicate ramifications of the vessels and their numerous inosculations with the bounding sinus are omitted.

being the smallest (fig. XLIX. 1—4); after the formation of the branchial fissures they lie behind the sickle-shaped branchial arches (figs. XLI. XLV. *B*, XLII.); they unite on either side upon the vertebral column into a radix aortæ, or aortal root; the two aortal roots blend more posteriorly, and form the aorta in common (fig. XLIX.). The vascular arches undergo considerable changes in the course of the fourth day: the first pair gradually disappears and is at length obliterated, and the second becomes smaller; but on either side there is a fifth arch formed, which becomes larger on the fifth day, whilst the second now disappears, so that on this day there are three vascular arches present, all of nearly equal magnitude (fig. XLIV. *A*, h^1, h^2, h^3). The carotid, and by-and-by the vertebral, arteries now make their appearance, arising from the aortal roots, and the bulbus aortæ undergoes a division into two passages. On the fourth day the aorta gives off distinct vessels between the several divisions of the vertebræ; it then divides and furnishes two principal branches, which go off in transverse directions (fig. L. *c*, XLIX. *i*, *i*, XLI. *m*, *m*, XLVIII. *f*, *f*), and splitting into branchlets, form an extremely beautiful network upon the outspread germinal membrane; the aorta afterwards proceeds, first divided and then single, along the vertebral column, gives off a mesenteric artery (fig. XL. XLV. *B*, d^5), and finally splits into two branches that ramify upon the allantois (figs. XLIII. XLVII. *n*). Almost simultaneously with the formation of the arteries an accompanying system of veins is developed; the veins of the germinal membrane, however, are so far in opposition

Fig. XLIX.

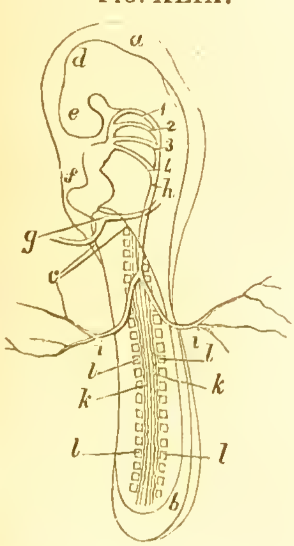

Fig. XLIX.—Embryo of the yolk depicted in fig. L. seen from the abdominal aspect, magnified. *a*, Vagina s. involucrum capitis; *b*, vagina s. involucrum caudæ (*a* and *b*, folds of the germinal membrane enveloping the head and tail); *c*, *c*, anterior passage of the involucrum capitis into the lateral involucra; *d*, vault of the mass appertaining to the corpora quadrigemina; *e*, anterior cerebral mass or lobe; *f*, heart; *g*, termination of the venous trunks in the future atrium cordis; *h*, aorta; 1, 2, 3, 4, the four branchial arteries; *i*, *i*, arteries of the blastoderma; *k*, *k*, translucent crests of the dorsal laminæ, rendered somewhat wavy by the water in which the embryo is immersed; *l*, *l*, vertebral laminæ.

to the arteries, that whilst these are directed transversely towards the sinus terminalis (fig. XLVIII. *f*,*f*), those run parallel with the long axis of the embryo; one inferior, larger vein lying on the left (fig. XLVIII. *g*, XLI. k^2), to which comes a second, smaller, often scarcely perceptible one, situated on the right, and either one or two superior veins (fig. XLVIII. *g*, *g*, XLI. k^1) bringing the blood from the vascular area to the heart. The system of the venæ cavæ is evolved in the body of the embryo at a still earlier period than the arterial system, and the portal system is distinctly separated on the fourth day and ramifying in the liver. The circulation upon the germinal membrane is therefore a vitellicular circulation; the blood courses from the embryo through the two arteriæ vitellinæ *s.* omphalo-mesentericæ (fig. XLVIII. *f*, *f*), to the sinus terminalis or vascular circle, which on the fourth day appears quite full of blood; from this the blood is returned to the heart through the four venous trunks,—the venæ vitellinæ *s.* omphalo-mesentericæ (fig. XLVIII. *g*, *g*, *g*). The smallest arteries and veins also communicate with one another by their most delicate extremities, and form a beautiful rete with rhomboidal-shaped meshes [125].

§ 58. There is a very peculiar formation belonging to the fœtus alone, and having a temporary or transitory character, which must now be mentioned, namely the *Wolffian bodies,—corpora Wolffiana,*

[125] Reichert states that but three branchial vascular arches exist on either side, and that they move gradually more and more backwards, so that the evolution of new arches and the disappearance of older ones are merely apparent. In my earlier researches, I conceived that I saw four vascular branchial arches existing simultaneously in the manner I have figured them; I have never observed five arches, although Baer speaks of them as so numerous.

Fig. L.

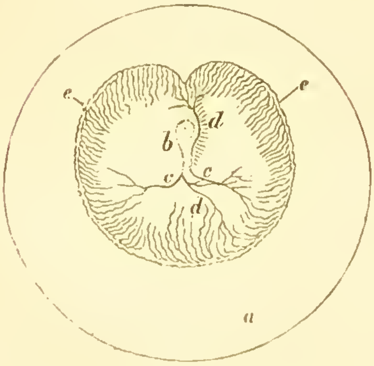

Fig. L.—Yolk of the hen's egg, of the natural size, but flattened through loss of support, at the beginning of the third day of incubation, exhibiting the earliest traces of the circulation.—*a*, Vitellus; *b*, embryo; *c*, *c*, arteries of the blastoderma; *d*, *d*, veins of the blastoderma; *e*, *e*, sinus terminalis.

or primordial kidneys[126]. These bodies are a product of the vascular membrane, though the serous layer would also seem to have some share in their formation. They make their first appearanee in the second half of the third day, as a pair of narrow but thick striæ, whieh sprout outwardly from each mesenterie lamina, in the angle formed between this and the ventral lamina in the line of the vertebral eolumn, from the region of the heart as far as the allantois. Even at this early period they exhibit interchanging elevations and notches, and a canal or duct running in the line of their long axis. On the fourth day the corpora Wolffiana are reeognized as being formed out of hollow eœeal-like appendages, which are attached along the eourse of the duet or canal (fig. XLIII. *q, q, q, q*); on the fifth day they look very broad and thick, and the eœcal appendages are convoluted. The germ-preparing sexual organs, the *testicles* and *ovaria,* make their appearance as delicate striæ on the inner sides of the eorpora Wolffiana[127].

§ 59.—The metamorphoses of the mucous layer of the germinal membrane begin, during this period, with the formation of the *intestinal canal.* After the mucous layer, above the involucrum eapitis, has struck in under the head, and formed the *anterior access* to the intestinal canal,—*aditus anterior ad intestinum* (Bacr), *fovea cardiaca* (Wolff), the same layer also bends in at the opposite extremity, over the involucrum caudæ or caudal envelope, and here forms thc posterior access to the intestine, *aditus posterior* (Baer), *foveola inferior* (Wolff); by the inereased curvature of the embryo, and the growth of the ventral laminæ, these depressions form funnel-shaped hollows, which terminate, in blind extremities, towards the head and tail. Almost simultaneously with the formation of the branchial fissures, or perhaps a little earlier, the space between the fore end of the head and the heart grows thin, and the mouth and fauces break through, so that a free communication results betwixt the fovea cardiaea and the cavity of the amnion (fig. XLV. *B, h*). The intestinum

[126] Casper Frederick Wolff is the discoverer of the bodies which have received their title after him. Vide his *Diss. sistens Theoriam Generationis*, Halæ, 1759. Valentin has given a very complete history of their discovery and development, —*Entwickelungsgeschichte*, p. 235.

[127] The corpora Wolffiana are also described at great length by Müller, in his account of the formation of the genital organs *(Bildungsgeschichte der Genitalien)*, where he has also given the most complete view we possess of the development of the sexual organs of birds.

rectum, on the other hand, (the posterior funnel-shaped involution of the mucous layer) continues longer closed. By the formation of the mesenteric laminæ the mucous layer is detached from the ventral laminæ, and pushed downwards (fig. XL. *A*, under *e*); as soon as the mesenteric laminæ have coalesced, the mucous layer also converges from both sides under the mesentery, and where it is accompanied by the prolongations of the vascular lamina, which proceed from the mesenteric laminæ, two new laminæ present themselves, the *intestinal laminæ*,—laminæ intestinales, which run perpendicularly downwards (fig. XLV. *A*, under *h*), and the mucous layer being thus bent inwards in a canalicular manner, forms the *intestinal cleft*,—an open canal in communication with the yolk, running forwards funnel-shaped towards the faucial cavity, and backwards in the same manner to the rectum. At the beginning of the fourth day, the intestinal cleft has contracted, and exhibits but a very small opening, which, extending soon after into a canal or sac (fig. XLIII. *k*, *l*) passes over the peripheral mucous layer as the *intestinal canal* (fig. XLV. *B*, *n*), and throws itself completely around the yolk. The oral and faucial cavity gapes widely, and extends into a narrower part or canal, the œsophagus, from which, inferiorly and posteriorly, a diverticular sacculus sprouts (fig. XLV. *B*, *i*), the first rudimentary appearance of the *lungs;* a little farther on, an elongated enlargement of the intestine is perceived, which indicates the situation of the future *stomach* (fig. XLV. *k*); the intestine then expands, and goes off funnel-shaped towards the yolk (fig. XLV. *n*, and in a later form, fig. XLIII. *k*, *l*), and in like manner towards the rectum, which still terminates in a blind sac; the limits between the small and large intestines are indicated by the evolution of a couple of diverticula,—the *capita cœca*, towards the end of the third day. About the middle of the third day, various other parts are indicated in connexion with the intestinal canal, which enlarges in the places where these are to appear, and sprouts out towards or into the vascular layer; thus, two little hollow off-sets show themselves as the rudiments of the *liver*, in which a venous net-work by and by appears, that resolves itself into the portal system. At the beginning of the fourth day, the two lobes of the liver appear as lappets of some breadth (fig. XLIII. *i*), in which the composition, by means of an aggregation of blind sacs, is apparent somewhat later; another small off-set or hunch also shows itself in the vascular layer, between the lobes of the liver; this is the *pancreas* about to be; it grows slowly, but, on the fifth day, when the *convolutions of the small intestine* begin to

be formed, it has enlarged considerably; at this time, the *spleen* also makes its appearance as a small red body. The pulmonic sac divides, and becomes more distinct, from the œsophagus appearing first pinched off from that part, and then provided with a pedicle, —the future *trachea;* on the fifth or sixth day, the lung of the one side is completely distinct from that of the other, and each is attached to the common pedicle by a particular branch, the future *bronchi;* the pedicle has farther extended, as the *trunk of the trachea.*

In the course of the first half of the third day, a small vesicular-looking protuberance arises from the intestinum rectum (fig. XLI. *n*); this proves to be the *allantois,* which grows into the caudal involucrum, and distends it. The allantois is covered externally with a stratum of the vascular layer (fig. XLV. *B*, *e*, *d*,) which it carries with it in its growth. The growth of this part is very rapid in the course of the fourth day (fig. XLIII. XLVII. *n*,) forcing its way through the caudal involucre, and the part by which it is attached being drawn out into a hollow pedicle. The external covering from the vascular layer shows ramifications of the aorta, which form a beautiful vascular rete. On the fifth day, the allantois presents itself as a large pedunculated bladder protruding from the umbilicus (fig. XLVI. *b*), which, bending to the right, has penetrated between the mesenteric and ventral lamina, and lies betwixt the amnion and the serous envelope. At this time, the allantois is nearly as large as the entire embryo (fig. XLVI.), being almost five lines in diameter [128].

§ 60. *Third period in the history of the development of the incubated Egg: From the commencement of the circulation in the allantois to the exclusion of the Embryo.*

The third and last period comprises the interval from the sixth to the twenty-first day. The two first days, however, comprehend almost all of general physiological interest which happens in this period, so that a shorter review of the grand features of the changes which take place in the embryo and ovum through its course will be sufficient. If the egg be opened at the beginning

[128] According to Rathke, the lungs are evolved from the first as a pair; he describes them, on the fourth day of the incubation, as two small, laterally compressed, thin laminæ, tapering off from before backwards, and ending in a blunt point, which spring from the œsophagus; see his paper on the development of the respiratory system in birds and the mammalia (*Ueber die Entwickelung der Athemwerkzeuge, &c*, in *Nov. Act. Acad. Nat. Cur.* vol. xiv. p. 170.) Baer also speaks of the lungs as originating in two hollow sacculi, which lengthen with rapidity into a hollow peduncle, *Entwickelungsgeschichte*, ii. 126.

of this period, it must be done with great care, as the albumen has now entirely disappeared, and the embryo lies close to the membrane of the shell; the vitellary membrane has become exceedingly thin, is very easily torn, and indeed is soon resolved entirely; the air-space at the blunt end of the egg has greatly increased in size. The germinal membrane now extends over the whole of the yolk; or the mucous layer of this part has almost entirely grown around, and so given origin to a sac-like covering, the *vitellary sac* (vitelliculum, or vitellicle, Owen), which encloses the yolk; the vascular layer has grown around nearly two-thirds of the yolk. The sinus terminalis of this layer is now a mere seam in the periphery of the area vasculosa, and in the course of the next few days disappears entirely; the veins, and then the arteries of the vascular layer of the vitellary membrane disappear somewhat later. On the other hand, the allantois is growing with great rapidity, and, on the sixth day, forms a pretty large flattened bladder (fig. LI.) which, however, in the course of the seventh

Fig. LI.

Fig. LI.—Embryo of the fowl with the allantois, *a*, already of great size, and depressed or flattened, the umbilical vessels, *b*, branching over it; *c*, external ear indicated by a depression; *d*, cerebellum; *e*, corpora quadrigemina; *f*, hemispheres.

Fig. LII.

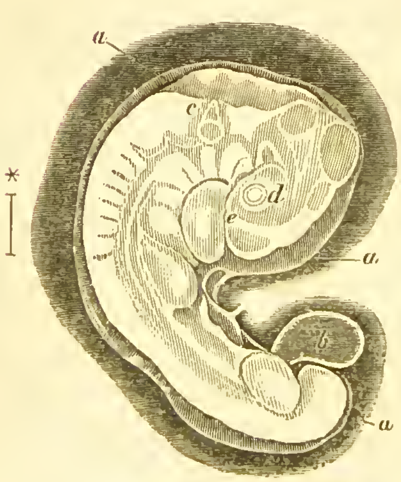

Fig. LII.—Embryo of the jackdaw (*corvus corone*) nearly four lines in length, drawn under the simple lens, the amnion, *a*, *a*, surrounds it closely on every side; the allantois, *b*, protrudes from the abdominal sulcus; the extremities are visible as simple lamellæ; numerous segments of the vertebræ and the several cerebral cells are conspicuous (vide figs. XLI. XLII. &c.); behind the corpora quadrigemina appears the cerebellum, and then the depression for the fourth ventricle; the ear is seen as a pediculated vesicle, *c*, springing from the medulla oblongata; under it lie the branchial arches and fissures; *d* is the eye; *e*, the nasal fossa, behind which the heart is perceived.

day, acquires nearly twice its former size, and inclines so much to the right side, that with the amnion, it covers the embyro completely, and comes in contact superiorly by means of its most vascular side with the serous envelope, which is consequently now completely separated from the amnion, to the formation of which it had in the first instance contributed. After the rupture of the vitellary membrane, all that remains of the albumen collects at the sharp end of the egg, and is now much more consistent; the yolk, on the contrary, has become much thinner and more diffluent, and the number of its globules has very greatly diminished; the embryo lies more towards the blunt pole of the egg, and on the sixth day, after breaking open the shell, the first

Fig. LIII.

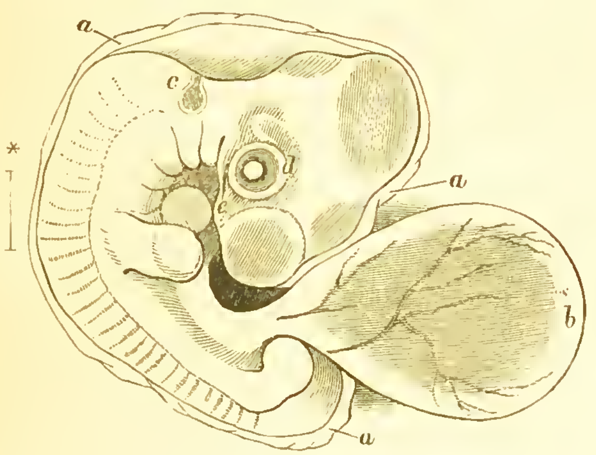

Fig. LIII.—An embryo similar to the last, but somewhat further advanced. The references are the same as in fig. LII.

Fig. LIV.

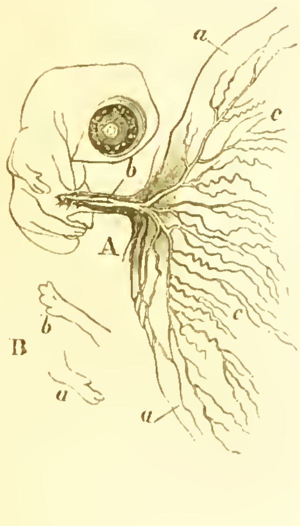

Fig. LIV.—Chick with part of the yolk *a, a,* which communicates by means of the delicate vitello-intestinal duct, with the noose of the jejunum *b,* which at this time lies within the funis umbilicalis; *c, c,* vasa lutea. *B,* separate views of the anterior extremity, which shows a distinct division into three digits, and of the posterior extremity, which shows traces of four digits.

appearances of motion are observed in slight twitchings of the extremities [129].

§ 61. The most remarkable metamorphoses of the individual organs on the sixth and seventh days are the following: the spinous processes are now formed on the vertebral arches; the rudiments of the ribs become more conspicuous; the immediate tegument of the brain and spinal cord is perceived to be composed of two layers; the largely developed corpora quadrigemina seem to advance with less rapidity of growth towards the end of the seventh day, and the hemispheres soon equal them in size (fig. LV. *c, c, d, d*); the fornix is evolved over the still open third ventricle; the corpora striata and thalami become conspicuous; the optic nerves, distinct from one another at first, now become connected in the chiasma; the infundibulum is still deep and wide; the pituitary body appears; the cerebellum is formed; but the fourth ventricle is still widely open, and passes over into a deep posterior furrow of the spinal cord. The eye is developed in every part, and is very large; the external opening of the ear is conspicuous, and in connexion with the auditory vesicle the semicircular canals and cochlea are formed; the nasal depression has lengthened downwards into a nasal passage, which runs between the superior maxillary bone and the frontal process, the opposite halves of which have now become united. In the extremities, the arm and thigh, both extremely short, can be distinguished; in the hand the rudiments of the three digits, and in the foot those of the four toes, can be made out (fig. LIV. *B*). The amnion is more and more distended, and at the umbilicus is brought more together, so that it

[129] The whole of this period is so well described by Baer, and his observations and my own agree so completely, that I have had little to do but to follow him in the preceding paragraph.

Fig. LV.

Fig. LV.—An embryo somewhat older than that represented in fig. LI. surrounded by the amnion as an ample vesicle: *a*, the amnion; the eyes, *b, b*, are very large; *c, c*, the corpora quadrigemina, now scarcely larger than the hemispheres, *d, d*; the space between them is the third ventricle.

becomes drawn out into an umbilical cord, in which lie the peduncle of the allantois and a noose of the intestine (fig. LIV. *A*, *b*); the neck advances in its evolution, and the lower jaw bones are elongated and assume the fashion of a beak. The heart acquires the form it possesses in after-life, the several parts having approximated and become more closely conjoined: the auricles are divided, and cover the ventricles, which can now even from without be perceived to be double; the aortal bulb at the same time appears produced from both ventricles in an arched form, arising directly over the septum, and being divided into two canals, the separation between which becomes visible outwardly on the seventh day; the pericardium is formed. From the aorta there now arise but two vascular arches on either side, and to the right a middle third arch; this and the two anterior arches are the later chief divisions of the aorta, and are filled by the stream of blood transmitted from the left ventricle; the two posterior arches are supplied on the seventh day with blood exclusively from the right ventricle of the heart, and are the future pulmonary arteries; the arches all terminate in the descending aorta. The Wolffian bodies, and the formations that take place upon or in connexion with them, have many remarkable relations during this period. The shut sacs of which they are composed become longer and more tortuous; they evidently secrete, and with their elongated common ducts, to which they look as if they were attached, terminate in the cloaca; betwixt their component shut sacs numbers of small points, which consist of little convoluted hanks of vessels, in every particular like the Malpighian bodies of the kidney, may be observed. The kidneys show themselves behind and above the Wolffian bodies on either side of the spinal column; at first they are lobulated greyish masses, which sprout by the outer edges of the Wolffian bodies; this is plainly to be seen on the sixth day, perhaps even sooner; the ureters are formed afterwards as their especial excretory ducts. The kidneys arise as independent formations; and, independently of them, the capsulæ suprarenales are evolved on their upper or anterior edge. The reproductive organs, which had appeared as little marginal lappets, now form two longish-shaped white bodies, and lie behind the suprarenal capsules, at some little distance from these, on the inner edge of the Wolffian body; they are still of like size, and it is impossible to distinguish whether testicles or ovaria will be produced; so that of all the principal organs the genital are those that are the latest recognizable in their rudiments, and distinguishable in their future special forms. The vessels of

the allantois are developed with great vigour; two arteries arise from the aorta, and a large vein runs on the under edge of the liver to the vena cava, along with the hepatic vein. The vessels of the allantois become the umbilical vessels.

The alterations that transpire in the mucous layer are of less moment: the organs already formed increase in size; the faucial cavity is elongated as the oral cavity in the bill-shaped maxillæ; the œsophagus extends; the division into crop and muscular stomach is distinguishable; behind the loop for the duodenum, and which encloses the pancreas, the jejunum forms a noose of the same length and tenuity, which lies completely out of the abdomen within the umbilical cord, where, by means of a delicate short conduit, it communicates with the vitellicle or yolk-sac,—the *ductus vitello-intestinalis* (fig. LIV. *A*, *a*). The liver is large and gorged with blood; the trachea and lungs are entirely separated from the œsophagus; the larynx makes its appearance as a small enlargement upon the trachea [130].

§ 62. The principal changes from the ninth to the eleventh day are as follow: the hemispheres of the brain enlarge greatly, at the cost, apparently, of the corpora quadrigemina, and span the third ventricle posteriorly; the cerebellum increases, particularly in its middle or vermiform portion, by which the fourth ventricle is now completely hidden; in the spinal cord the enlargements corresponding to the two pairs of extremities, become more conspicuous; the fibrous structure of the brain and spinal cord is apparent; the eyes proceed in their development, and attain still more colossal relative dimensions; the eye-lids appear as a circular-shaped fold of the skin; the external organ of hearing increases in width and depth. The bulbs of the feathers become apparent in certain districts, first along the middle line of the back, upon the haunches, and over the rump; the joints of the extremities are more solidly and distinctly evolved; the muscular parts are very apparent, and separated into bundles under the skin; the nerves are more conspicuous, and the motions of the embryo are stronger; the neck lengthens greatly. In the heart the external separation of the bulbus aortæ into two distinct canals follows; the vessel proceeding from the left ventricle gives off larger carotids from its anterior arch; on these appear the little thyroid bodies. These two aortal

[130] The observations of Müller on the formation of the genital organs and corpora Wolffiana, agree with my own in every respect. On the same subject see Baer, l. c.

arches (*trunci anonymi*) represent the earlier third branchial vascular arch; the asymmetrical vascular arch that appears behind them, on the right side, is the future aorta descendens. From the stem arising out of the right ventricle proceed the two most posterior (the earlier fifth) of the branchial vascular arches; they do not yet give off any pulmonary branches, and still terminate posteriorly in the aorta; at a later period they become the proper pulmonary arteries. The corpora Wolffiana become shorter, and smaller every way, and their excretory duct longer; the kidneys increase in size. The germ-preparing sexual organs begin about this time to differ manifestly in their form: the testicles become elongated, cylindrical, and continue of equal size; the ovaries remain flattened, grow unequally, the right first ceasing to make any progress and then disappearing, the left enlarging proportionally with the other parts. The oviducts are distinct, but the right, like the ovary to which it corresponds, is arrested in its development. The gall-bladder becomes conspicuous as a diverticulum of the biliary duct. The *bursa Fabricii* emerges from the cloaca; the allantois grows still more over the embryo. The vessels on the vitellary membrane, especially on its under surface, are numerous and large; the veins are turgid and tortuous (fig. LIV. *A*, *c*), and appear stained of a yellow colour, whence they are often called *vasa lutea*.

§ 63. It is in the course of the last days of the second week that the epidermic formations are produced,—the feather bulbs, the nails, and the scaly coverings of the feet; ossification also begins in many bones, the muscular parts get stronger, the eyelids are well formed, and in the ear the tympanum has appeared. The Wolffian bodies are ever shorter and smaller; the testes acquire their excretory ducts; the left ovary is conspicuous, and the corresponding oviduct is hollow, whilst the same parts on the right side have shrunk entirely. The intestine makes several turns outside of the umbilicus, and continues in communication with the vitellary sac by means of the vitellary duct; upon the inner surface of the vitellary sac, and over the tortuous veins, membranous productions—puckered or wrinkled folds—make their appearance; and at the same time similar formations occur upon the mucous membrane of the intestine. The allantois has now grown completely around the embryo, so that the ovum—the vitellary sac, the remaining albumen, &c. included—is completely enveloped anew as it were, and will now retain its form even after the shell

is removed (fig. LVI. *b*; from the Kestril,—*Falco tinnunculus*); the serous covering disappears.

§ 64. In the beginning of the third week, the embryo, straitened for room, from the transverse axis of the egg comes more and more into the long axis, which it finally fills; the head is turned towards the breast, and mostly lies under the right wing; the allantois has inclosed the whole embryo and vitellary sac, and having contracted adhesions with itself forms an uninterrupted cyst or envelope for the entire contents of the egg, being everywhere in immediate contact with the membrane of the shell, from which it must be peeled when they are separated; in the interior of the allantois, white flocculent precipitates from the urine occur, and these accumulate at length to such an extent that they conceal the embryo in a greater or less degree. The allantois, as the

Fig. LVI.

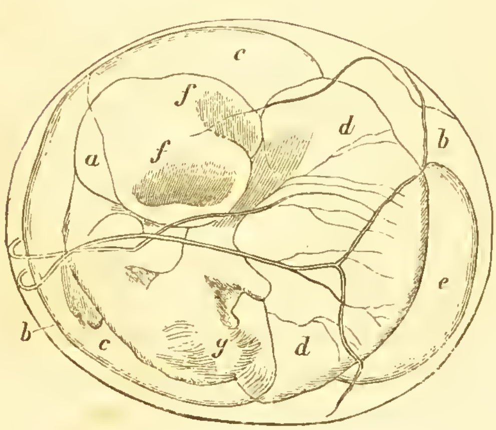

Fig. LVI.—Embryo of the *Falco tinnunculus*, much farther advanced than that of the fig. LV. It is represented inclosed in its membranes, and of the natural size, but being removed from the shell, its weight has caused it to spread, and to look longer than it is in fact. The embryo of this falcon, by reason of the transparency of the membranes, is peculiarly fitted to serve for the demonstration of the relative position of the several parts: *a*, the embryo shining through the membranes; *f,f*, the eyes, of great size, seen from above; *b, b*, the allantois, has grown completely around the embryo, and so forms a perfect envelope, the chorion, whose principal vascular branches are perceived; *c, c*, the amnion; *d, d*, the yolk-sac; *e*, the albumen; *g*, the coccyx, with the feathers beginning to sprout.

Fig. LVII.

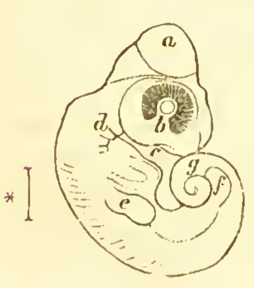

Fig. LVII.—Magnified view of the embryo of the *Lacerta agilis*, two and a half lines in length, for contrast with the other embryos figured: *a*, corpora quadrigemina; *b*, cleft of the eye; *c*, olfactory depression; *d*, branchial fissures already disappearing; *e*, anterior extremity; *f*, hinder extremity; *g*, tail.

complete fœtal envelope, is entitled the chorion. In the brain, the corpora quadrigemina, whieh have remained very mueh behind in development, are thrown backwards under the hemispheres; the pineal gland and eerebellum increase; the latter beeomes marked with deep seissures. Over the eye, the eyelids grow till they meet, but without uniting; the iris advanees, the eornea rises, the lentieular prominence remains, whilst the lens recedes, and so the anterior chamber, whieh had hitherto been wanting, is produced; there is no appearance of pupillary membrane. In the ear, the labyrinth beeomes osseous at the beginning of the third week. In the heart, the valvular system is evolved; the anterior arteries are detached more and more from the descending aorta, and disappear altogether towards the end of the period; the pulmonary arteries beeome mueh larger, and their terminations in the aorta have contracted and beeome mere anastomosing channels—*ductus arteriosi.* The kidneys grow rapidly. The eorpora Wolffiana shrink eontinually, but in male embryos they may still be deteeted as rudiments near the testes, even after the epoeh of fœtal life is over. The right ovary, as has been stated, is arrested in its growth, and is soon after birth completely absorbed; the right oviduet also disappears, although a trace of it may be discovered in some birds at every period of their life. From the testes delieate vasa efferentia are developed, whieh, after passing through the Wolffian bodies, unite into a filiform vas deferens, whieh in its turn is evolved out of, or, more correctly, in the excretory duet of the Wolffian body. The vitellary sae shrinks more and more, its eontents diminishing in quantity and beeoming still more eonsistent. It is drawn into deep saeeulated compartments by the main trunks of the umbilical vessels; the albumen and amniotie fluid are lessening eontinually in quantity. The tegumentary umbilieus is still freely open at the beginning of the last week; and with the advaneing growth of the intestinal eanal, a greater number of convolutions of the bowel pass out of the abdominal cavity; on the nineteenth day the prolapsed intestine returns in some degree into the abdomen again, and draws the yolk, with whieh it is still in uninterrupted connexion by means of the very considerable vitellary duct, along with it into the belly, upon whieh the mucous and vascular layers of the vitellary sae follow, whilst the serous layer increases, beeomes thieker, and detaches itself from both the other layers. The whole vitellary sae is not thus taken up into the abdomen, only a part of it enters, and this expands in the eavity, whilst the part that is excluded is cut off by the eontracting umbilieal ring.

The vitellary duct is of considerable width and arises funnel-shaped from the intestine; long after birth there is still a little diverticulum of the jejunum to be discovered in its former situation; nay, in some birds this diverticulum continues through life as a normal feature in their structure. The communication with the vitellus is at length obliterated, becoming a mere thread, on which a yellow knot, the last remains of the yolk, may not unfrequently be observed [131].

[131] There are two remarkable points in the above paragraph, which well deserve more particular consideration, from the light they are calculated to throw on the history of malformations from arrest of development: these are the deficiency in the right ovary and oviduct, and the persistence of the vitellary diverticulum in certain cases. I instituted researches upon these points in a considerable number of birds in my *Contributions to the Anatomy of Birds,* contained in the *Abhandlungen der Academie zu München,* II. 273 (1837). Later inquiries have only confirmed and extended the facts and views there announced. Notice of a few of the facts will suffice in this place. In all birds the rudiments of two ovaries and oviducts, symmetrical and of a size, are evolved; the degeneration and absorption of those on the right side occur among the several orders at different times, earliest among the passeres, the grallæ and palmipedes, and always during the fœtal period; later, and some time, longer or shorter, after birth, among the rapaces; here, indeed, it happens not unfrequently that the right ovary, in point of structure duly developed, and even containing true primary ova, which, however, do not seem susceptible of fecundation, exists through life; I have detected such a rudimentary formation at every period of life in many of the Falconidæ—in the buzzards particularly, and in the *falco gypäetus,* likewise in many owls, and among the parrots; Nitsch also discovered it in the eagles (I failed to find it in *pandion,* at least). In the *Falco palumbarius, F. nisus, F. æruginosus,* &c. the right ovary is regularly developed, and produces vitelli as proper for fecundation, apparently, as those of the left; of the right oviduct, however, either no trace, or a mere rudiment only, can be found. In those falcons even in which at a later period neither ovary nor oviduct occurs on the right side, their rudiments may still be found long after the fœtal period is at an end; in the half-fledged and fully-fledged nestling, they will usually be observed of about half the size of the corresponding parts on the left side. About this time the ovula become visible in the left ovary as dark masses, but not in the right, where the formative power is extinct, and no histological change occurs. The relations between the jejunal diverticulum, as the remains and representative of the ductus vitello-intestinalis, have a similar though opposite character. This part usually disappears in the rapacious, climbing, and singing birds, within a few days after birth, and seldom continues longer recognizable; it remains somewhat longer in many of the gallinaceæ, grallæ, and palmipedes; in the herons it is sometimes present, sometimes absent, and varies greatly in length, capacity, and form, in different individuals,—it occurs of one line and three lines in length. In many marsh and water-birds, as in the coot family, in the goose, but particularly in the Numeniadæ, this part continues to grow even after birth, attains to half an inch or an inch in length, communicates freely with the intestine, and continues through life as a normal delicate cœcal appendage; it

§ 65. *Birth of the Chick.*

Two days before its exclusion, the chick may occasionally be heard chirping feebly within the shell, for the chorion (the allantois) is readily torn by the point of the beak, which then comes into contact with the air contained in the air-chamber; along with the imperfect respiration that now goes on, the circulation through the umbilical vessels proceeds unimpeded. The violent motions of the chick occasion cracks in the shell; the beak assists, and holes are produced. The bill, so soft in all other parts, is furnished at this period with a very remarkable, hard, horny process near its point, evidently to enable the young creature to break through the shell, for the process in question falls off very shortly after the escape of the bird. The labour of getting free from the shell generally lasts half-a-day; at length the upper part is raised, the chick pushes out its feet, draws its head from under its wing, and erecting itself quits the shell completely. The remainders of the chorion and amnion, which, with the closure of the umbilicus, could no longer be nourished, shrivel, fall off, and are left behind in the shell [132].

§ 66. *Physical and Chemical changes in the Egg during Incubation.*

Various physical and chemical changes take place in the egg during the period of incubation. It loses weight: in the first week, to the extent of five per cent.; in the second, the amount is thirteen per cent.; and in the third, sixteen per cent. So that an

even presents determinate generic characters in regard to form and size, precisely as the cœcal appendages of the colon; in all the Fulicariæ, or coots, for example, it is very long, but delicate and narrow; it is more funnel-shaped in Numenius. With regard to the metamorphosis of the excretory canal of the Wolffian body into the vas deferens, the question may be found discussed in Müller (l. c. p. 32), who maintains, in opposition to Rathke, that the vas deferens is no new production, but a simple transformation of the excretory canal of the Wolffian body. To me, however, it appears that the vas deferens does arise as a solid thread in or upon the excretory duct of the body in question, a view in which Rathke seems now to participate. Vide in Burdach's *Physiologie*, ii. The decision of this point is of importance, as bearing upon the entire subject of development; and in reference to the question, as to how far new formations are to be regarded as transformations of pre-existing organs, or as arising severally and independently. On this point, vide the *General Physiology*, book iv.

132 Baer has given a very detailed account of all that transpires shortly before the exclusion.—*History of Development*, i. 137.

incubated egg, with an embryo ready to emerge from it, is altogether lighter than one that is just laid; a new-laid egg sinks in water, —an egg at the end of the period of incubation swims. The cause of this loss of weight lies in the evaporation of the watery part of the albumen; the same thing happens, though more slowly, in unincubated eggs from keeping; the greater rapidity of the loss in the incubated egg arises merely from the greater heat to which it is subjected. Another consequence of the evaporation is the formation and rapid enlargement of the air-space, which, as we have seen (§ 47), is first produced after the egg is laid. It is probable that the evaporation in question is connected with chemical changes, for the air contained in the blunt end of the egg is not simple atmospherical air, but contains a larger proportion of oxygen, the amount varying between 25 and 27 per cent. This hyper-oxygenated air serves the embryo in the process of respiration, or aeration, that is carried on by the medium of the allantois; for eggs may be incubated to the perfect maturity of the embryo, even without the contact of the external atmospheric air, and may be hatched alike well in pure oxygen and in various irrespirable gases; for example, pure hydrogen, nitrogen, &c. At the beginning of the incubation the fluid albumen contains a small quantity of oil, apparently communicated to it from the yolk; when the incubation has advanced considerably, the albumen loses almost the whole of its water and salts (§ 21); these seem to be transferred to the yolk, which admits of explanation, for the vitellary sac bursts and draws the albumen, now changed into a thick mass, into it. By this accession of matter, the yolk enlarges during the first half of the period of incubation, but becomes thinner; the incessant demand upon it, however, for materials for the growth of the embryo, causes it again to shrink and to become more consistent towards the end of the period (§ 64). The proportion of chemical elements of the vitellus and white vary considerably; the quantity of phosphorus contained in the albumen lessens, but increases in the yolk, and again appears in combination with oxygen and calcium as a phosphate of lime, which in the period of the ossification is plentifully required for the consolidation of the bones; as the quantity of lime contained in an egg at the time it is laid is extremely small (§ 21), and becomes very large at a subsequent period, the earth must be acquired in some way with which we are not at present well acquainted. As it is not very probable that the lime is derived from the shell, it may perhaps be produced from other matters under the influence of the organic agencies;

the same may be said of the iron, the quantity of which increases greatly during incubation [133].

CHAPTER II.

History of the development of the Human Embryo, with supplementary matter from the history of the development of Mammalia.

MATERIALS.

§ 67. Ever since the restoration of the sciences, the most distinguished anatomists and physiologists of their times have devoted themselves to the study of the development of the human embryo. In the descriptions and representations which they have left us among their writings, of preparations obtained from the

[133] However scanty and fragmentary our knowledge of the very remarkable chemical changes undergone during incubation, and however much all that has been reported on the matter wants confirmation and extension, still what we do possess is of exceeding interest. It seems impossible to mention any subject in organic chemistry which, carefully pursued, promises more copious results than the study of the alterations of the egg during incubation. For the particulars given above we are indebted almost exclusively to Prout.—Vide *Philos. Trans.* 1822. Bischoff was the first who discovered the fact of a larger quantity of oxygen being contained in the air of the air-cell, and the accuracy of the observation has been confirmed by Dulk. The experiments of Ehrmann, first communicated in the *Isis*, 1818, p. 122, showed that fecundated eggs might be incubated under irrespirable gases. [For Dr. Paris's analysis of the air contained in the air-chamber, see annot. 114, p. 88. The statement in the text, that eggs can be incubated to perfection in pure oxygen and neutral irrespirable gases, is certainly an error. The experiments of Schwann (contained in his *Diss. De necessitate aeris atmospherici ad Evolutionem Pulli in Ovo*, 4to. Berol. 1834,) have set the question for ever at rest, and demonstrated *that they can not.* In eggs *effectually* excluded from the contact of atmospheric air, no part of the future embryo is ever formed; the trifling changes that actually take place in the state of the cicatricula and halones probably only occur in virtue of the oxygen of the air-chamber. The law which declares the contact of oxygen necessary to the life of all that is organized, is so universal, that the experiments of single individuals ought never to be held as of any weight against it. Ehrmann erred and came to wrong conclusions, from not taking precautions against the *penetration* of the gases he used by the air of the atmosphere. Varnishes of organic animal matters, such as *albumen, gelatin,* &c. have no effect in preventing this *endosmosis* of different airs; and it was from overlooking this fact that Mr. Towne (*Guy's Hosp. Repts.* vol. iv.) erred. Had he *greased* his eggs, his results would have been different; every dairy-maid knows that an egg which has been well greased to make it keep, will not produce a chick when set under a fowl, but will in due season become addled.—R. W. Mr. Towne's very recent experiments only show that eggs

bodies of women who had died or who had miscarried at different periods of their pregnancy, we have a great mass of materials, but they are merely fragmentary, and very dissimilar in point of worth. The rare occurrence of opportunities to examine the bodies of women who have died in the earlier periods of their pregnancy in a recent state; the uncertainty of all observations made on ova which have been cast off by abortion; the difficulty of drawing correct inferences in regard to the mode of origin of certain formations from their anatomical characters only; finally, the prejudices and preconceived opinions of writers, and the false views of things, correctly observed in themselves, to which these lead;—such are the chief obstacles that oppose themselves to a connected and clear apprehension of the first stages in the development of the human embryo. We are therefore, and almost of necessity, here compelled to have recourse to the mammalia as sources of information, and not only in regard to these earlier periods, but even as concerns much later stages in the history of development; and there can be no doubt that researches on the mammalia carefully conducted, and used with discretion, are much better calculated to throw light on the primary formation of the human embryo than any amount of necessarily unconnected observations on human ova cast off at an early period, and in the great majority of cases obviously diseased. The history of the evolution of the human fœtus at later periods is so complete in itself, from the number of observations we now possess, that there is scarcely any necessity for recurring to the mammalia in regard to it. In treating the whole of this subject, the history of the development of the chick is still the safest guide, and to this we shall therefore continually refer[134].

which have been coated over with albumen and covered with several layers of paper dipped in that fluid, can be incubated to the complete evolution of the embryo; not that the embryo can be produced without all access of atmospheric air.—R. B T. With regard to the supposition that the lime which enters in such large quantity at last into the body of the chick is produced "*from other matters under the influence of the organic agencies*," this is quite inadmissible in the present state of chemical science. Neither indeed is there any occasion for such an impossibility. The shell of the fully incubated egg is always light, brittle, and spongy, and careful investigation would certainly show that all the lime in the composition of the chick was derived from this source.—R. W.]

[134] The works that treat most fully of the matters now to engage us are the Physiology of Burdach, ii. and the Manual of Development of Valentin (*Handbuch der Entwickelungsgeschichte des Menschen*), Berl. 1835. The greater number of the newer elementary works on physiology, based on individual observation, have not yet reached the subject of development. Döllinger only in his Elements of Physiology, (*Grundzügen*, 1st part, 1835,) and Heusinger in his *Notes*

§ 68. *Earliest appearances of Conception in Mammalia; detachment of ova; production of corpora lutea.*

At the season of heat in mammalia, individual ova come to maturity in the Graafian vesicles; after the intercourse of the sexes an increased flow of blood takes place to the ovaria; the vascular membrane of the Graafian vesicle enlarges; the granules or

to a Translation of Majendie's Physiology, 2d vo . 1836, treat this subject by the way, and briefly. Among the elementary anatomical works, that of Lauth, *Elémens d'Anatomie Pratique*, 2d vol. 1836, contains a short but very precise, clear, and comprehensive account of the evolution of the fœtus, illustrated by diagrams. In Weber's edition of *Hildebrandt's Anatomy*, there is an excellent account of the evolution of each individual organ or system, and of the anatomy of the fœtal membranes. Among iconographic works, that of Dr. Wm. Hunter, *The Anatomy of the Human Gravid Uterus*, fol. max. 1774, deserves particular mention as unsurpassed in accuracy of representation and beauty of execution. The best figures of the external forms of the embryo are still those of Soemmering, *Icones Embryonum*, 1799. Among later works, that of Velpeau, entitled *Embryologie ou Ovologie humaine*, Paris, 1835, must be mentioned. Many of the earlier ova there represented are certainly diseased. The *Etudes Anatomiques, &c. de l'Œuf* of Breschet, Paris, 1832, are distinguished by the excellence of the representations of healthy as well as of diseased ova. The work of Seiler, entitled, "The Uterus and Ovum of Man in the earlier months of Pregnancy," (*die Gebärmutter und das Ei des Menschen in den ersten Schwangerschaftsmonaten dargestellt*,) Dresden, 1832, contains several beautiful and faithful figures; unfortunately the work is not finished. The subject is treated systematically and iconographically in Flourens' *Cours sur la Génération, l'Ovologie, et l'Embryologie, publié par Deschamps*, Paris 1836; but imperfectly and without reference to the latest discoveries. The same may be said of the production of M. Coste: —*Embryogénie comparée; Cours sur le Développement de l'Homme et des Animaux*, tom. i. Paris, 1837,—a work which, with a little of high pretence, certainly contains much valuable matter, illustrated by good figures in connexion with the development of a few of the mammalia, viz. the sheep, the dog, and the rabbit; but in which the development of the human embryo is most imperfectly and unsatisfactorily treated. For the most important and also the latest contributions on the developement of the mammalia of all orders and also of man, we are beholden to Baer (*Entwickelungsgeschichte der Thiere*, 2 Bde, 4to, Königsb. 1828—37). These are contained in the second volume of his great work, which it is much to be regretted is yet unfinished, and unprovided with explanations of the plates. Kilian, in his *Geburtshülflicher Atlas*, 1837, has given an excellent selection of the best plates extant of the fœtus and uterus, to which he has added many of interest peculiar to himself. I have here mentioned only the very principal works that treat of development; in no part of anatomy and physiology perhaps are the materials so widely scattered through periodical publications, contained in small tracts, &c.: the chief contributors in this way are Bojanus, Meckel, E. H. Weber, Rathke, Burdach, J. Müller. [T. Wharton Jones, M. Barry, and C. Reichert.]

eells mingled with its eontents, beeome greatly developed and altered [135]; and a thiekening and general increase of its walls, partieularly of the base and sides (fig. LVIII. *B*, *b*, from the bitch), ensue, precisely as in the eapsule or ealyx of the bird (fig. IX. *a*, p. 38); the ovum and other eontents of the folliele are by this pressed forwards, or against that aspeet of the folliele whieh is in eontaet with the peritoneum, and whieh now beeomes eontinually thinner and thinner, and finally bursts, so that the ovum eseapes (fig. LVIII. *B*, *d*; fig. XIV. *c*, p. 46), and a eavity is left in the ovary (fig. LVIII. *c*, LIX. LX. *a*, and XIV. *b*;) this is soon obli-

[135] In a bitch forty-eight hours after intercourse, I found the Graafian vesicles of three or four times their original dimensions, and surrounded by a vascular rete, as is described and figured with reference to birds. (fig. XXIV.) The granules of the contents had become large oval cells, completely filled with dark molecules, and the nucleus as clear as a transparent vesicle, so that these cells bore the strongest resemblance to the pigmentary cells of the choroid of the eye (fig. LXI.); some of the cells were smaller, paler, and without any darker molecular contents.

Fig. LVIII.

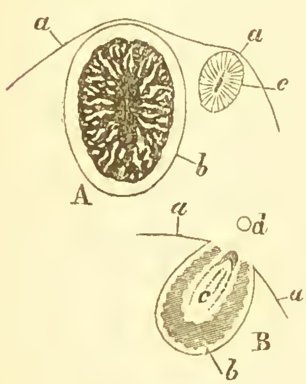

Fig. LVIII.—A section of a portion of the ovary of the sow; *a*, *a*, investing peritoneum; *b*, recent corpus luteum full of black blood; *c*, older corpus luteum; *B*, Graafian follicle of the bitch, just burst, magnified and partly as a plan, after Baer; *a*, *a*, investing peritoneum; *b*, fleshy mass formed around the walls of the follicle; *d*, the ovulum which has escaped.

Fig. LIX.

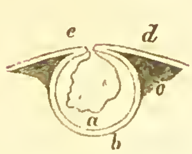

Fig. LIX.—A corpus luteum from the body of a female who destroyed herself by drowning, eight days after impregnation; *a*, mucous tunic of the Graafian vesicle sprouting from the circumference towards the centre; *b*, external tunic of the Graafian vesicle; *d*, investing membrane of the ovary; *c*, ovarian stroma; *e*, point at which the ovulum escaped from the Graafian follicle. (After Baer, in *Siebold's Journ. f. Geburtschulfe*, b. xiv. t. i.)

Fig. LX.

Fig. LX.—Section of a Graafian vesicle of a female, who also committed suicide by drowning, having been in the company of an admirer the day before. The inner membrane *a*, is thickened, and in folds; *b*, the outer membrane; *c*, ovarian stroma. (After von Baer, in *Siebold's Journal*, u. s.)

terated, by the growth on all sides of the inner membrane of the follicle—a reddish fleshy-looking mass sprouts from the walls towards the shrinking cavity, and the rent by which the ovum had escaped is finally closed[136]. An ovarian follicle thus altered

[136] In addition to the matters in the text, Baer goes on to say :—"The empty capsules in birds do, in fact, occasionally assume the appearance of the corpora lutea of the mammalia, especially when the edges of the cicatrice, as happens occasionally, again coalesce. But, even when the edges do not coalesce, the shrivelled and greatly diminished calyx, which also acquires a yellow colour, bears a striking resemblance to an unclosed, but very small corpus luteum of a mammiferous animal," *Entwickelungsgeschichte*, p. 182. Corpora lutea are always to be viewed as so many indications of previously fecundated and ruptured Graafian vesicles. Meckel, in his *Anatomy*, vol. iv. p. 686, says :—"I am strongly inclined to regard all the accounts we have of differences in the number of corpora lutea, and the young produced, as the effects of imperfect or erroneous observation; in more than two hundred instances in which I have examined the ovaria of women who had had families, and of the females of mammalia of different kinds which had been pregnant, I have, without any exception, found the number of corpora lutea to correspond with the number of children, or of the young that had been borne. The best observers—Haller, Hunter, came to the same conclusion."

[There are, however, other opinions on the cause and mode of formation of the corpus luteum, besides that given in the text and note above, which it seems right to mention here. Dr. Montgomery, of Dublin, for instance, holds, that it is no increase or production of the inner coat of the Graafian vesicle, but a new formation between the two layers of membrane composing that cyst (*Exposition of the Signs of Pregnancy*, p 219. 8vo. Lond. 1837). Dr. R. Lee again concludes from his observations, that the body in question is formed around, or on the outside of both coats of the vesicle, the yellow matter deposited being in immediate contact with the stroma of the ovary (*Med. Chirurg. Trans.* vol. xxii. Lond. 1839). Dr. Paterson, the last writer on this subject (*Obs. on Corp. Lutea*, in *Edinb. Med. and Surg. Journal*, for January, 1840), espouses Dr. Montgomery's conclusions. "It is the vascular *covering of the ovisac*," says Dr. Barry, "which becomes the corpus luteum, not the inner membrane of the Graafian vesicle, for that inner membrane is constituted by the ovisac itself, which disappears."—*Researches*, 2d series, p. 318 and 350. The views of British inquirers are essentially the same; the difference between them merely refers to the parts which each assigns to the Graafian vesicle and to the ovary, connected with their skill severally in splitting these into layers. Whether the deposit take place around one or two coats of the Graafian vesicle is perhaps of little moment; it is certainly on the outside of so much of the Graafian vesicle, viz. the lining membrane of the cyst, as nature has no farther use for, the end of the deposit being doubtless to isolate from the rest of the organism that which has already fulfilled its office. And here the interesting question presents itself in regard to the significance of corpora lutea under any circumstances. We have seen recent general opinion to be, that ova are normally cast loose at each menstrual period in women, and each season of heat in animals (Annot. 88, to § 33). The breach in the ovary which is the consequence of this phenomenon must be repaired, and it would actually seem to be made

is known by the name of *corpus luteum;* in man, and many mammalia, the colour is yellow at length; in others, it is reddish or whitish. In many mammalia, the corpus luteum grows to a considerable size; in the sow, for instance, the corpora lutea continue for some time after the separation of the ova in the form of large livid or purplish red berries (fig. XII. *a*, *a*, p. 45), their cavities being filled with coagulated blood, which occasionally exhibits a peculiar dendritic appearance (fig. LVIII. A, *b*.) By the side of the more recent corpora lutea it is usual to find smaller shrunk bodies of the same kind, the results of former conceptions (fig. XII. *b*, *b*), which are really yellow, and about half the size of ripe unemptied follicles (*c*, *c*, *c*); when cut across, they show the mode in which they have been consolidated by the growth of the inner parietes, which have filled the cavity completely, nothing being left of it save a little cleft or cicatrix (fig. LVIII. *A*, *c*). The mechanism, by which the ova in the mammalia are cast loose from the ovary, would therefore appear to differ much less from that which obtains among birds than might at first sight be imagined. By the growth of the walls of the calyx or capsule, the yolk in birds is carried outwards, pressed against the peritoneum, and pushed from the stroma (§ 48); in mammalia, the process is in every particular the same; the identity of the process is even more striking, when animals, which have a

good in the same way, but somewhat modified, as the rupture in the ovary which is the effect of impregnation. Physiologists, at the present day, therefore, very uniformly recognise *true* corpora lutea, and *false* corpora lutea, the former being the effect of impregnation, the latter of the escape of an ovum that has not felt the influence of the male. *True* corpora lutea are, at first, much larger than false corpora lutea; they are also of a pretty regularly round figure; they present concentric radii when divided perpendicularly; their centre is occupied by a distinct membrane (the lining membrane of the Graafian vesicle,) they have a puckered central cicatrice, and they are never numerous. *False* corpora lutea again are small and irregular in form; they want the central cavity lined with a distinct membrane; they show no puckered central cicatrice, and no concentric radii on the surface of a perpendicular section; finally, they are frequently numerous and demonstrable in both ovaries. R. W.]

Fig. LXI.

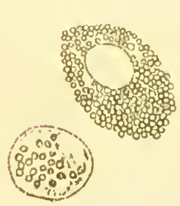

Fig. LXI.—Two cells from the granular membrane of the fœcundated Graafian vesicle of a bitch, forty-eight hours after conception. The larger cell surrounds a very bright nucleus, and is filled with dark molecules, so that it bears a strong resemblance to a pigmentary cell of the choroid coat of the eye.

scanty ovarian stroma, and in which the follicles are pediculated like berries, as in the mole, and still more in the ornithorhynchus (fig. XIII. *a*, p. 45,) are contrasted; the ovaria, in these creatures, are extremely like those of birds (fig. XXIV.); the difference between them lies almost solely in the presence of the additional particular granular mass in the Graafian follicle of the mammal *.

§ 69. *Progress of the Ovum in the Fallopian tube, to its arrival in the uterus.*

Of all the particular points in the history of development, the reception of the ovum by the Fallopian tube, and its progress to the uterus, are those that still lie hidden in the deepest obscurity. No one has yet succeeded in discovering ova in the Fallopian tube of the human subject; all the accounts of such a thing having actually been seen are more than doubtful: even in the mammalia, among which the precise moment of impregnation is known, it is one of the most delicate and difficult of anatomical researches to discover bodies so minute as the ova in the Fallopian tubes. It would appear, too, that the term at which the ova arrive in the uterus is not precisely the same even in the same species of animal; it may vary several days in every kind; in rabbits, for instance, the ova reach the uterus from the third to the fifth day after impregnation; in the bitch, the period is much longer, the ova not attaining the uterus till after the lapse of ten or twelve days. In the animals just named, the earliest periods in the development of which are the best known, several ova are detached, and arrive successively, rarely together, in the uterus; and it would seem that the Graafian vesicles do not, by any means, all give way at the same time, but that individual follicles burst several days earlier than others. During the whole of this period, the infundibulum of the tube or oviduct grasps the ovary, and adheres to it closely, so that the ova, as they escape from the vesicles, necessarily pass into its abdominal extremity. To what extent the muscular contractions of the Fallopian tubes, or the ciliary motions of their epithelial indusia contribute to the farther

[* The ovum is expelled from the Graafian vessel, owing to a *vis à tergo* produced by the thickening of the base and sides of the vesicle. This *vis* acts, of course, not upon the minute ovum only, but upon the contents of the vesicle at large, which are, therefore, in part at least, expelled along with the ovum. R. W.]

progress of the ova is unknown. Occasionally the ovaria remain for weeks closely grasped by the infundibula of the tube.

With regard to the ova themselves, they [were believed, till very recently, to] undergo but little alteration during their passage through the tubes; they carry off a small portion of the granular stratum of the vesicle with them, which appears hanging to them at first as an irregular, ragged discoidal appendage (fig. LXII. and LXIII.), but this is soon detached; with this the chorion enlarges; the stratum that surrounds the vitellus becomes more consistent, and does not escape along with the thinner contents when the ovum is punctured; the ovum gains a little in size, too, during its progress through the tube, perhaps by absorbing the fluid resembling thin albumen, which is shed into the tube at this time; the yolk becomes more readily separable from the chorion; there is still no trace of any especial spot where the embryo arises [137].

[137] Dr. Bischoff, of Heidelberg, has kindly transmitted to the author an account of a complete series of observations upon ova, in their progress through the Fallopian tubes, in the bitch, of which an abstract follows. Dr. Bischoff says:—"With regard to the period at which the ovum escapes from the ovary, I believe I may safely aver, that it is very various, and often both much earlier and much later than is generally believed. The earliest period at which I have observed it to occur is thirty-six hours after intercourse; this was in a pointer bitch (Spitzhundin), which belonged to the servant of our anatomical

Fig. LXII.

Fig. LXII.—A fully ripe ovum from the ovary of a rabbit in heat, surrounded by the proligerous disc, magnified 290 diameters. The cells of the disc are crowded with molecules, but their boundaries are not discernible, from the ovum being drawn, still included within the Graafian follicle; in the vicinity of the germinal vesicle, the vitellary fluid is perceived almost wholly free from granules, vide fig.

[The enquiries of British embryologists have shown the ovum to be the seat of very great and important changes, both before it is

theatre, and who had taken a note of the precise time of the coitus. The ova were, in this instance, already in the middle of the tubes. In another bitch, which I examined nineteen hours after intercourse for the first time, the ova had not yet escaped from the Graafian vesicles, six of which, however, were very much enlarged, but still completely closed; I detected the ovum in each of these. In another young bitch, which had not suffered any dog to approach her for fourteen days, although she was still in heat, and a bloody fluid escaped from the vagina, I found the ova, to my great astonishment, still in the middle of the tubes, as in the case examined after a lapse of only thirty-six hours. In another bitch, which had not submitted to the male for eleven days, the ova were still very backward, having just passed from the tubes into the uterus. These three last mentioned cases were all first conceptions; the animals were all young, and had not previously had litters. In older bitches, on the other hand, I generally found the ova farther on than I had expected. I am inclined to believe that age is the principal cause of the differences observed in this respect: in young bitches, impregnated for the first time, the ova are both detached from the ovaries later, and move through the tubes more slowly than in older animals, which have already littered once or oftener. Besides this, the degree of the heat, as already remarked by Von Baer and by Guenther, appears to have some influence. To discover the ova in the tubes, I begin, by removing these from the ovaria and all connected parts, so that all tortuosity disappears, and nothing remains adherent to them. I then stretch them out with a pin or pins at each end upon a red or black waxen tablet, and slit them open from the abdominal

Fig. LXIII.

Fig. LXIII. *A, B.*—An ovum of a rabbit not quite ripe, magnified 290 diameters, removed from the Graafian vesicle, and burst under the compressor,—*a, a,* granules or cells of the proligerous disc; *b,* the thick chorion [?] (zona pellucida); *c,* rent in this membrane, through which the contents of the vitellus, and the germinal vesicle *d,* has escaped; the nucleus of the germinal vesicle is apparent as usual as the germinal spot *e*; *B,* highly magnified granules from the contents of the Graafian vesicle; *a,* the granules without preparation; *b,* the granules treated with dilute acetic acid, and the involucre of the cell thereby separated slightly from the nucleus.

cast loose from the ovary, and during its passage through the Fallopian tube. In the ovary it acquires an outer membrane, which

end onwards with a pair of fine sharp scissors. I now search every fold of the divided tube with care, and have almost always been so fortunate as to discover all the ova in the tube, generally at no great distance from one another. It is only necessary to be well acquainted with the appearance of the ovarian ova, and to have a quick eye, in order to succeed. The ova of the bitch, by reason of the denseness of their vitelli, are perhaps more easy to find than those of any other animal, which causes them to look like white points. I then remove the ova carefully with a needle to a glass tablet, and examine them as quickly as possible under the microscope, without addition of any kind, as I find that fluids of every description cause changes in the ova, particularly in the form of the yolk; saliva causes, perhaps, as little change as anything, and this I use when moisture becomes indispensable. The highest point at which I have found ova has been about the upper third of the tube, which was in a bitch thirty-six hours after her first intercourse, and in another, which was killed during the continuance of the heat, but without my having had an opportunity of knowing the exact time of the intercourse. All the ova I have found in the tubes have borne a strong resemblance to those of the ovaria; they all presented a granular disc, exactly like that which they exhibit in the ovary, and the vitellus was always opaque and dark. The earlier of them also showed almost no alteration in point of size, and in the appearance of the vitellus. But I searched with the greatest perseverance, and with every possible precaution, for the germinal vesicle, in vain. I believe, therefore, that I am in a condition to announce the disappearance of this structure in the ova of the mammalia as an ascertained fact, whereas it has hitherto only been presumed hypothetically, or from analogy. In the pregnant bitch which I examined nineteen hours after the first intercourse, and in which I found the ova still in the ovaria, these still contained their germinal vesicles. The germinal vesicle, therefore, in all probability, only disappears on the escape of the ovum from the ovary. What becomes of it I cannot positively say; I feel persuaded, however, that it bursts, and that its contents, mixed with the sperma of the male, form the macula, from which the development of the embryo proceeds. The farther changes which the ovum undergoes in its progress through the oviduct, are the following:—1. It increases in size, but not very remarkably. 2. The yolk obviously acquires greater consistency, its granules cohere more strongly. When an ovarian ovum is ruptured with a needle, the vitelline granules immediately escape, and diffuse themselves in the water; but I have divided impregnated ova of the tube with the needle into two, four, or six pieces, without the vitellus becoming diffused; the portion of yolk connected with each little segment remained adherent to it, and seemed quite coherent; when forcibly mixed with water, still the granules did not separate completely; they always remained in groups or clusters.—3. Changes in the form of the vitellus takes place. Whilst this part in ovarian ova lies close to the inner surface of the vitelline membrane,—I mean the chorion or zona pellucida,—this was only the case in the earliest ova from the tubes; in all the others it seems to quit this surface in different points, and, instead of its original round form, it now looks angular and uneven. I have occasionally observed such remarkable forms, that I asked myself the question, whether the vitellus of the mammiferous animal's ovum underwent changes of form similar to those of the ovum of fishes and batrachia?

in the tube becomes swoln with moisture, and assumes the appearance of a thick gelatinous-looking membrane—the PROPER CHO-

Unfortunately these forms of the ova are very rapidly lost, when the ova are moistened with water or saliva, apparently from imbibition of the fluid. I have not found it possible, on this account, to make drawings of several of the forms I have observed.—4. In many of those ova from near the uterine end of the duct, I have imagined that I could distinguish a very delicate membrane surrounding the vitellus internally. I could never succeed, however, in isolating this membrane, or seeing it by itself, so that I dare not speak on this point more decidedly.—5. On the other hand, it is quite certain, that the ovum receives no new external covering in the course of the duct or tube; it acquires no albuminous layer or membrane like that which lines the shell in birds; and I can therefore state positively, that the outer covering of the ovarian ovum also remains the outer covering (always putting the decidua out of the question) of the tubular and uterine ovum through all its stages,—a fact, which Von Baer, Wagner, Coste, and others, had merely spoken of as probable. Mr. T. Wharton Jones, the only observer who believes that he has seen this formation of albumen and membrane, was probably deceived by the disc. He has either not been sufficiently well-acquainted with this part from the ovary onwards, or no longer expected it in the impregnated ovum (as it actually does disappear at a later period), and has taken its granules for the albumen forming around it." Little can be added to these laborious and careful researches of Bischoff. Whether there be any mistake or not about the alteration in the form of the vitellus must be determined by future inquiry. I have not yet, myself, succeeded in discovering ova in the tubes, in the few attempts I have made in this direction. Among the older inquirers, De Graaf (op. cit.) followed the first stages in the conception of the rabbit with diligence; and, had he but been acquainted with the true ovum, and examined it microscopically, we should long have been in possession of the wished-for information. Three days after intercourse, De Graaf found the ovary closely embraced by the infundibulum of the tube, and one ovum in the tube, and two in the uterus of the right side. Cruikshank, who repeated De Graaf's experiments with great care, on many occasions found ova in the infundibula, on the third and fourth days after intercourse; they appeared to have increased somewhat in size. Prevost and Dumas found the ova in the tubes in bitches eight days after intercourse (*Ann. des Sc. Nat.* vol. iii. p. 122) Baer found the ovule in the tubes of a bitch; it was only slightly enlarged, and appeared somewhat loosened in its texture, in comparison with its form and appearances in the ovary; he also observed the ovum of a sheep in the same state, even before the end of the first day; the proligerous disc (the granular disc) was much loosened and diminished. *Entwickelungsgeschichte*, ii. p. 183. The period during which the infundibulum grasps the ovary, also appears subject to great variations; a fact, which was remarked by most of the old observers. Baer says, that in the sow, the ovary generally continues embraced for about four weeks; in the sheep, the period is nearly the same. This, however, is not invariably the rule; I have found it free in the sow eight and ten days after intercourse.

[The observations of Mr. T. Wharton Jones, alluded to by Dr. Bischoff, were to the effect, that, having found ova in the Fallopian tubes, near where they enter the horns of the uterus in a rabbit, the third day after impregnation, he saw these ova remarkably different in their appearance from the ova as they exist in

RION. By and by the zona pellucida, which is visible at first, having disappeared, the newly-formed chorion comes to be the

the ovaries themselves. In addition to the component parts of the ovarian ovum, he perceived that they had a thick transparent investment similar to that which is observed in the ovum of the frog. Subsequent observations led Mr. Jones to conclude, that this additional transparent investment was acquired in the ovary, that it was different from the zona pellucida, which he regards as the proper vitellary membrane, and that this new investment, and not the zona pellucida, formed the proper chorion. In one observation, made on the rabbit seven days after impregnation, he found the new transparent investment indicated, to constitute the sole covering of the yolk, but it formed a large cavity when compared with this part in point of size. Here he supposed the zona pellucida to have disappeared, in the same way as he directly observed it to do in the ova of the newt. In a human ovum, aborted at a very early period, the same careful observer farther found that the thick transparent membrane (zona pellucida), had disappeared, or been resolved into a gelatinous cellular tissue, which filled the new investment,—the chorion. Imbedded in this peculiar tissue, a small round body was discovered, which proved to be the yolk now forming a spherical blastoderma. *Philos. Trans.* 1837, p. 339.

In § 20, and the annotations to it, particularly annot. 56, justice was not done to the highly meritorious observer whose name has but just been mentioned—T. Wharton Jones: let it be rendered here. Wharton Jones was, beyond all doubt, the discoverer independently, but contemporaneously with others, of the germinal vesicle and germinal spot in the ovum of man and mammiferous animals. His observations were made in September 1834, and his discoveries were shown to many at the time and immediately afterwards: the present distinguished professor of General Anatomy and Physiology in University College, London, Dr. Sharpey, has informed the writer of this note, that he had seen Mr. Jones, in his demonstrations of the ovum in the sheep, turn out the germinal vesicle from its cavity, and indicate the germinal spot upon it, in the beginning of the month of February, 1835. Mr. Jones, in the course of the same month, embodied his observations in a paper which was sent to the Royal Society, accompanied with drawings of the various structures he had seen. The originals—the paper and drawings now in the archives of the Royal Society, have been inspected by the writer of this note, and there can be no doubt of the facts as stated. The views at this time current in Great Britain, with regard to the structure of the ovum, were those of Baer, and to the effect that the ovum of the mammiferous animal was the analogue of the Purkinjian vesicle of the bird's egg, the Graafian vesicle at large of the mammal being held as corresponding to the vitellus with its contents, in the bird. Mr. Jones had the honour, as an independent inquirer, of entering the field on this particular against Von Baer, and of fairly confuting him. Mr. Jones is therefore the original interpreter among us of the important discovery of Baer, and he is as much the discoverer of the germinal vesicle as Coste, or Bernhardt and Valentin, and of the germinal spot, as the author of this work. By some strange error Mr. Jones's paper was not printed in the transactions of the Royal Society, which it would have eminently graced. It only made its appearance subsequently in the pages of the *London Medical Gazette*, and it is by the kind permission of the editor and proprietors of this excellent

sole investment of the yolk. Several large and transparent vesicles arise in the centre of the yolk (fig. LXIV. *B*, *C*); by and by

periodical, that Mr. Jones's figures and explanations are here added. Mr. Wharton Jones has also the undoubted honour of having discovered the true chorion as a formation posterior to the act of impregnation. His view of the *zona pellucida* of the mammiferous ovum as the analogue of the *membrana vitelli* of that of the bird, is now also beginning to be admitted by all physiologists. There is no British physiologist to whom the science of Embryology stands nearly so much indebted as to Mr. Jones: he is not only the most original, but probably the most successful of all our inquirers into this difficult subject. R. W.]

Figures which illustrate Mr. T. Wharton Jones's paper, entitled, 'On the Ova of Man and Mammiferous Animals, as they exist in the ovaries before impregnation; and on the discovery in them of a vesicle analogous to that described by Prof. Purkinje, *in the immature egg of the Bird.' Read at the Royal Society,* 1835.

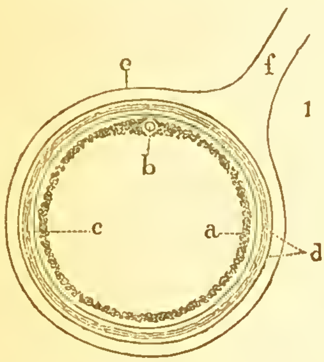

Fig. 1.—Diagram representing a section of the hen's egg within the capsule of the ovary, and the position of the vesicle of Purkinje.—*a*, The granulary membrane, forming the periphery of the yolk; *b*, the vesicle of Purkinje embedded in the cumulus; *c*, the vitellary membrane; *d*, the inner and outer layers of the capsule of the ovum; *e*, the indusium of the ovary; betwixt the indusium and the capsule the stroma is seated; *f*, the pedicle by which the capsule is attached to the ovary.

Fig. LXIV.

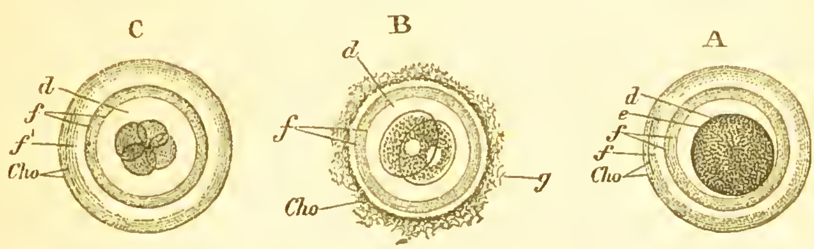

Fig. LXIV.—Ova of the rabbit from the Fallopian tube (after Barry). *A*, ovum of 35¾ hours, $\frac{1}{10}$th in diameter, found near the middle of the Fallopian tube; *B*, ovum found at the middle of Fallopian tube, more advanced than *A*; *C*, ovum also from Fallopian tube, and still more advanced than *B*; *cho.* chorion *f*, zona pellucida; *e*, vitelline membrane; *d*, yolk; *f′*, fluid imbibed by the chorion.

these disappear, giving place to a smaller and more numerous set (figs. LXVIII. and LXX.) which, in their turn, yield to others

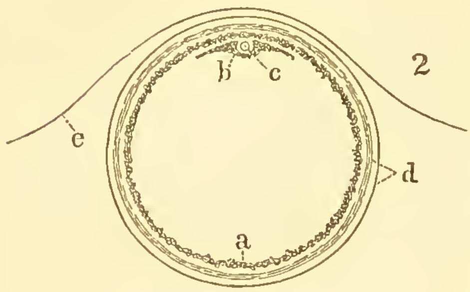

Fig. 2.—Diagram of a section of the Graafian vesicle and its contents, showing the situation of the ovum.—*a*, The granulary membrane; *b*, the proligerous disc; *c*, ovum; *d*, the inner and outer layers of the wall of the Graafian vesicle; *e*, indusium of the ovary derived from the peritoneum, the stroma immediately underneath which is condensed so as to form the *tunica albuginea*.

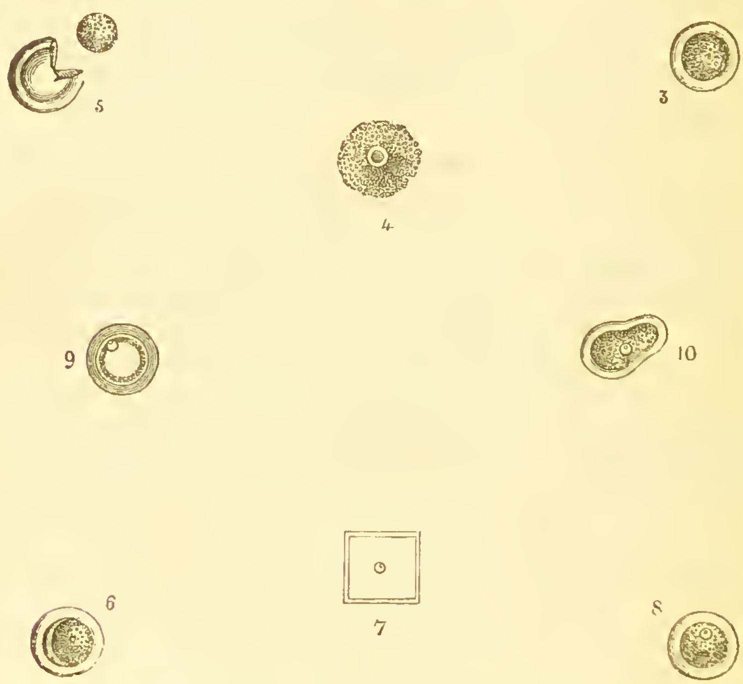

Fig. 3.—The human ovum as seen under the microscope by transmitted light, magnified forty-five diameters *. On one part of its surface a small spot is seen, which is the elevation on the side of the germinal vesicle [the germinal spot]. Fig. 4.—The ovum still surrounded by the proligerous disc, magnified about fifteen diameters. Fig. 5.—The outer envelope of the ovum lacerated, and the granulary membranous sac composing the yolk drawn out. Fig. 6.—A human ovum magnified forty-five diameters, in which the granulary sac is so much contracted that it does not fill up the whole cavity of the external envelope †. The spot on the

* The measurements given do not lay claim to any very great accuracy, as they were made with a micrometer glass under the simple microscope.

† The distention of the external envelope, by the absorption of water, and not the contraction of the granulary sac, may be the correct explanation of this appearance.

still smaller, and still more numerous (fig. LXV.) and the same thing happens repeatedly, until a coarsely granular structure is

surface of the granulary sac, which may be considered as the cicatricula, is the elevation on the side of the germinal vesicle. Fig. 7—represents, within a square area, the human germinal vesicle, magnified forty-five diameters. On one side of it is seen the small elevation, [the germinal spot]. Fig. 8.—A human ovum, magnified forty-five diameters. In it the grains composing the granulary sac were in such small quantity, and adhered so little together, that the whole germinal vesicle [with its spot], is seen shining through the outer envelope. Fig. 9 is a diagram of a section of an ovum, representing the thick external envelope, within which is the granulary sac, and, connected with the inner surface of the latter, the germinal vesicle. Fig. 10 represents a human ovum, which I found in the ovary of a married woman of about 30. It is somewhat like two joined together, but there is only one germinal vesicle.

Figures which illustrate Mr. T. Wharton Jones's paper, 'On the first changes in the Ova of the Mammifera in consequence of Impregnation, and on the mode of origin of the Chorion,' from Philos. Trans. 1837.


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Fig. 1, an ovum found in the Fallopian tube of a rabbit the third day after impregnation, magnified forty diameters.—Fig. 2, the ovum of the frog when recently laid, magnified two diameters.—Fig. 3, the ovum of a water-newt, in which development has commenced, magnified rather more than twice.—Fig. 4, a diagram showing the embryo of the newt after the vitellary membrane has given way, contained only within the cavity of the substance, which is added to the ovum in the oviduct.—Fig. 5, a diagram showing the embryo of the frog still

produced, which occupies the centre of the ovum, and of which each component vesicle contains a colourless, pellucid nucleus, and each nucleus presents a nucleolus. R. W.]

§ 70. *The Ovum in the Uterus to the Formation of the Embryo.*

As soon as the ova have passed from the oviducts or Fallopian tubes and reached the uterus, they begin to undergo the first remarkable changes and to grow with rapidity. The following particulars are given with an especial reference to the ova of the bitch and rabbit, the ova of these animals having been most frequently examined, and in their successive metamorphoses also presenting more numerous analogies to the ovum of man, than those of the ruminants. The ova still contained within the cornua of the uterus are found notably increased in size; here they are from half to three-quarters of a line in diameter, whilst in the ovary they measured no more than from the tenth to the twelfth of a line. It is easy to perceive that the outer coat or chorion expands and becomes thinner; the yolk enlarges and becomes more fluid, whilst the dark granules vanish and larger oil-globules make their appearance; the superficial granular layer of the vitellus at the same time acquires a membranous consistency, and the granules collect in heaps or clusters, which are divided from one another like little islands, and anon collecting in one particular part they form a darker circular spot, which in ova that have attained a line in size may be distinguished as a point with the naked eye (fig. LXVIII. *A, B*, fig. LXX. *A, B*). This macula or spot consists of a larger aggregation of granules, which rises slightly

surrounded by the vitellary membrane, as well as the gelatinous substance, which is added to the ovum in the oviduct.—Fig. 6, an ovum found in the horn of the uterus of a rabbit seven days after impregnation, magnified forty diameters.

Fig. LXV.

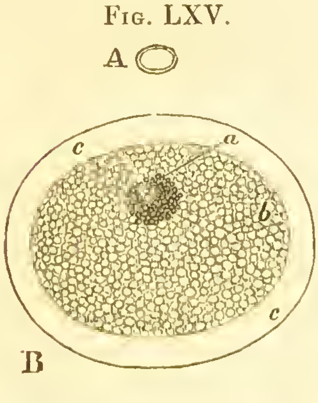

Fig. LXV. An ovum from the uterus, but still unattached; *A* of the natural size, *B* magnified; fourteen days after the first, eleven days after the last approach of the male; the granular rings have disappeared; the granular spot *a* has increased in dimensions; *b*, the vitellus; *c*, the chorion, which has become much thinner apparently, from the imbibition of moisture, is now at a considerable distance from the vitellus.

as a disc above the general level, from its being somewhat thicker than the rest of the membrane; it by and by becomes a little clearer in the centre, whilst the granules are clustered more closely ring-wise in the circumference (fig. LXV. *A* and *B*, more highly magnified fig. LXVI. *b*). The granules of this disc appear plainly to be cells having a small nucleus in the centre (fig. LXVI. *a*). The double membrane with which these small ova are enveloped, is rendered very distinct by putting them for a few seconds in water; here the outer coat (fig LXV. *B. c*), which is perfectly transparent and without visible structure, separates quickly from the inner coat which surrounds the yolk and supports the granular macula (fig. LXV. *B, b.*). The external membrane is the future CHORION, the inner the BLASTODERMA, which has already enveloped the entire vitellus, and even earlier perhaps surrounded this part as a continuous granular layer (vide annot. 62 to § 20); in the bird, on the contrary, (§ 47) the blastoderma only occupies a small part of the superficies of the yolk as a disc-like granular stratum. The space between these two coats (fig. LXV. between *b* and *c*), is in all probability filled with a thin stratum of albumen, which the ovum has attracted in the tube and beginning of the uterus, and which by imbibing water has swollen, and thus occasioned a greater separation between the two membranes of the ovum. The granular spot is the point from which the formation of the embryo begins, and which has therefore by some observers been called the *embryonic* spot. Whether the membrane which we have hitherto seen as the outermost continues so, resolving itself into the shaggy chorion, or there is another delicate membrane thrown around this as the

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FIG. LXVI.

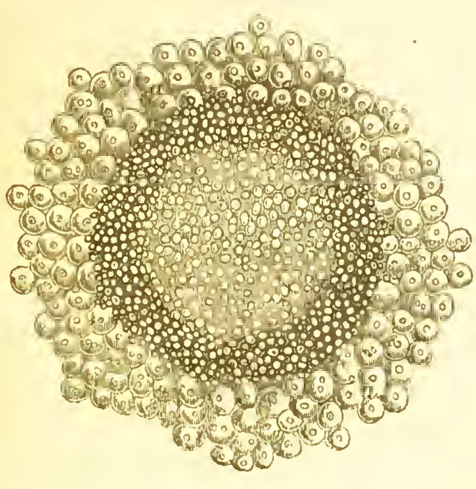


Fig. LXVI. The granular spot of the ovum last figured, magnified. It is seen to consist of cells with nuclei, *a*, in the circumference, and in the inner part of granulations, which are observed of different sizes and densities. These granules and cells together, form the rudiments of the germinal membrane (*blastoderma*).

true outer covering of the ovum—the exochorion—as some maintain, is doubtful. The former appears the more probable view. The ova still lie free and unconnected in the uterus; from having been round they now become oval in their form[138].

[138] I have made the above statements entirely from my own observations on the ova of rabbits and dogs. The figures of the ovum of the dog as given by Prevost and Dumas in the *Ann. des Sc. Nat.* t. iii. pl. 5, may be referred to in this place; as also my own representations of the ova of the rabbit and dog in my Contributions (*Beiträge*, &c.) tab. I. fig. 9, and likewise the descriptions and drawings of Coste (*Embryogenie*, pl. IV. V. VIII.) of the ova of the dog, sheep, and rabbit. It is Coste who calls the granular spot from which the formation of the embryo begins the embryonic spot (*tache embryonnaire*); Baer was before Coste in all requisite observations on this part in his *De Ovi Mammal. et Hom. Genesi*, p. 7—11. More recently Baer has given more extended remarks on the same subject, which in the main agree with all I have myself seen, *Entwickelungsgeschichte*, ii. p. 184. Baer, however, seems inclined to recognize the addition of a particular membrane, the analogue of the shell membrane of the bird's egg—Burdach's Exochorion—to the ovum of the sow and sheep: this membrane, he imagines, is added in the uterus, and an albuminous deposit thrown over it: this formation occurs in the sow on the thirteenth day, an epoch at which the ovum with its vitellus in this animal has become much elongated and filiform. Nothing analogous was observed in dogs and rabbits, and he is still doubtful as regards these animals whether he should admit a new formation, or allow of a metamorphosis of the earlier chorion [thick transparent membrane, zona pellucida] into the outer membrane of the more advanced ovum, the proper shaggy chorion (loc. cit. p. 187). From all that I have myself seen in earlier ova from the uterus, I must conclude that there is no new chorion formed; a conclusion with which the researches of Bischoff accord completely, and of which I am happy to be able to add an account from a manuscript communication of the author. "I have traced the ova," says Dr. Bischoff, "from their first entrance into the uterus from the tubes, quite high in the points of the cornua, to their attachment in their several resting-places. In one instance I found the ova still

Fig. LXVII.

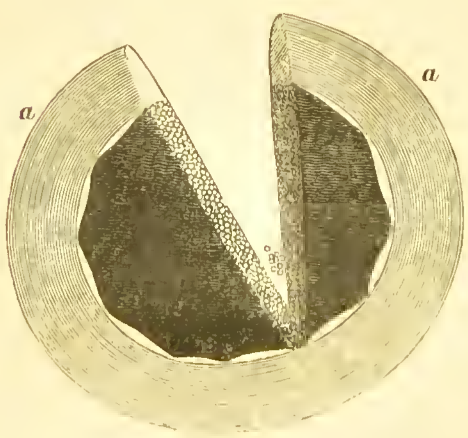


Fig. LXVII. Fecundated ovum of the bitch removed from the upper end of the uterus. The ovum has been flattened and split with a needle; the vitellus is polyhedrous, and shows an angular outline; its contents do not escape: *a*, the chorion or zona pellucida, of great thickness and breadth. The figure is greatly magnified.

First appearance of the Embryo, and farther development of the Ovum, till its attachment to the uterus.

§ 71. As the corroborative and mutually supplementary researches of a host of observers have made us most intimately

very close together, lying quite in the upper pointed part of the uterus, in a bitch which I was given to understand had been impregnated fourteen days before. If this were so, the animal must have been young The ova were still very small, and to the eye in search of them appeared as extremely minute white specks. The most remarkable circumstance I remarked was, that the disc had disappeared, it was not however included by a membrane, but the proper zona pellucida (the chorion, v. Annot. 59) still surrounded the ovum externally. The ovum, and particularly the zona, had increased in diameter (fig. LXVII. *a*). One of the more perfect ovarian ova measured the 0,0072 of a Parisian inch in extreme diameter, the zona included; the vitellus itself the 0,0056, the thickness of the zona being the 0,0005 of the same inch. The fecundated ovum in its extreme diameter, including the zona, measured from the 0,0082 to 0,0083, the vitellus itself from the 0,0055 to 0,0063, the zona in thickness the 0,0009 of a Paris inch. The separation of the yolk from the inner surface of the zona was more conspicuous now than it appeared subsequently, and now I thought I could no longer doubt of the presence of a fine enveloping membrane. The vitellus was of an irregular shape in all; in one this was particularly remarkable, a portion of it appearing to be pinched off from the rest; in another it looked almost as if it were eight-cornered; the vitellus, however, was still uniformly dark and opaque. The ovum generally was very consistent and elastic, for I could press it quite flat without bursting it; by which, of course, it increased very much in diameter. (Fig. LXVII. exhibits an ovum split with a needle, the yolk-granules not escaping, and the yolk itself angular in the periphery.) The observations I had occasion to make on another bitch which had been eleven days in my possession, and had not during that time suffered any dog to approach her, although she continued strongly in heat, corresponded closely with what is related above. The ova on the two sides showed a decided diversity in their conditions. On the left side there were two which plainly were referable to ova in the earlier period, save that they were both somewhat oval, and that in the one the vitellus had connected itself entirely with the one side of the zona. These two ova were near the middle of the left cornu, close to one another. In the right cornu there was one ovum obviously farther advanced; it lay as low as the lower third of the horn, was completely transparent, quite round, and about the third of a line in diameter. With my unaided eye I could perceive a white point or speck. This, under a powerful lens, had an extremely beautiful appearance. The vitelline granules had all, as it seemed, attached themselves in distinct rings to the inner aspect of the very delicate external covering; at one part there was a small agglomeration of granules (similar to that represented in fig. LXVIII. *B*, *c*). More closely examined, it appeared that to the outer envelope there was an inner one intimately applied, within or upon which the granular ring lay. This inner envelope showed less disposition to separate from the outer one when put into water than in more advanced ova. The ova in the right and left cornua uteri in this instance differed so much in their state of development, that I had no difficulty in detecting ova in another

acquainted with the ovum of the dog, a sketch of its evolution will, I imagine, be found very much in its place here. In all essential

bitch in a stage intermediate between them. The separation and arrangement of the vitelline granules in rings here appeared to have taken place from the middle towards the superficies. The rings ran very close to one another and were broad; the ova much smaller than the one on the right side in the preceding case, although larger than those of the left side. As they were almost completely transparent, the greatest attention was necessary to discover them in the uterus: in one point I also remarked an agglomeration of granules in this instance as in the former. When the ova had lain for a short while in water, they altered very much in shape; the particular aggregations of the vitelline granules were lost, and they collected again into a dark but very irregularly-formed mass. Here, again, I could not be quite certain that I saw any inner envelope." Instead of the drawings first sent to me by Dr. Bischoff as illustrative of the above particulars, I have given in figs. LXVIII. and LXX. drawings of a couple of ova communicated to me more recently, and with the following remarks appended:—" I believe I can now give you some particulars bearing on the formation of the blastoderma or germinal membrane. I have lately examined two bitches, in which the ova had just reached the uterus from the tubes, but very evidently were not all in the same stage of development. The ova appeared as small vesicles, clear as globules of water, with a scarcely-perceptible white speck on one side, from the 0,0125 to the 0,0150 of a Paris inch in size. Under the microscope the zona appeared already to have become considerably thinner (fig. LXVIII. *B*, *a*); the inner superficies was occupied with granular rings, among which one larger, darker granular spot (fig. LXVIII. *A*, *c*), and several smaller (*d*) were conspicuous. With the greatest attention I remarked in several of these ova certain

Fig. LXVIII.

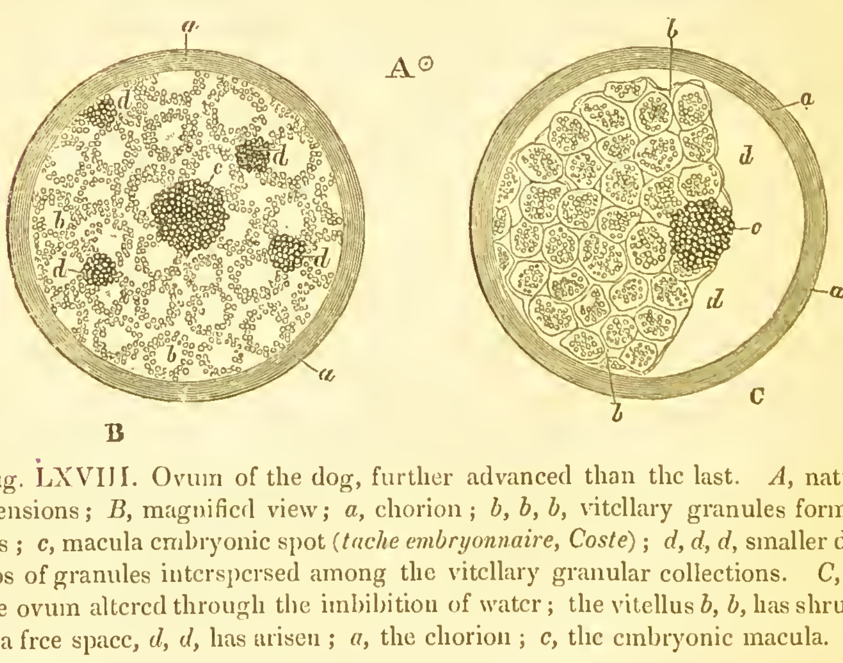


Fig. LXVIII. Ovum of the dog, further advanced than the last. *A*, natural dimensions; *B*, magnified view; *a*, chorion; *b*, *b*, *b*, vitellary granules forming rings; *c*, macula embryonic spot (*tache embryonnaire, Coste*); *d*, *d*, *d*, smaller dark heaps of granules interspersed among the vitellary granular collections. *C*, the same ovum altered through the imbibition of water; the vitellus *b*, *b*, has shrunk, and a free space, *d*, *d*, has arisen; *a*, the chorion; *c*, the embryonic macula.

points that of the rabbit, and even of the sheep, which, after the dog, are best known to us, will be found to correspond. The period

very delicate lines, drawn in circles around and including the granular rings. In water a delicate inner covering (fig. LXVIII. *B*, *c*) was detached from the outer one (*a*) as in the ova formerly studied; the inner vesicle shrunk together, so that an empty space (*d*, *d*) was produced between the two; along with this the regular arrangement of the yolk-granules disappeared. It required great pains to succeed in tearing the outer covering with fine needles, and the inner one partially, so as to obtain a view of the dark spot by itself and without intervention. I now saw clearly that even in these ova (as in those of greater age represented figs. LXV and LXVI.) the outer covering was entirely composed of vesicles or cells in close apposition with one another, and containing in their interior larger or smaller numbers of granules, which lost their regular arrangement in water and exhibited molecular motions. By this means, and also by rolling, I satisfied myself that the granules were not attached externally to, but contained within, the cells; I could discover no other more remote nucleus to any of these cells. I also found cells in the dark spot, and here they contained still larger quantities of granules, and lay one upon another. Between these cells containing granules, numbers of other smaller dark globules were perceived, composed of clusters of cohering yolk-granules, but surrounded by no particular covering; as these could be distinguished agglomerated, it was impossible that

Fig. LXIX.

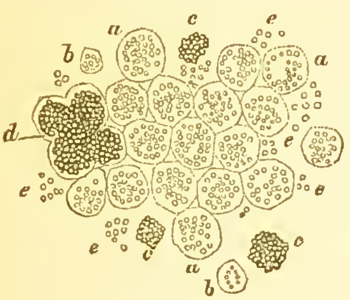


Fig. LXIX. Granular cells of the germinal membrane of the last figure, more highly magnified. *a*, Larger cells; *b*, smaller cells; *c*, granular globules without cells; *d*, cells of the embryonic spot; *e*, granules from ruptured cells.

Fig. LXX.

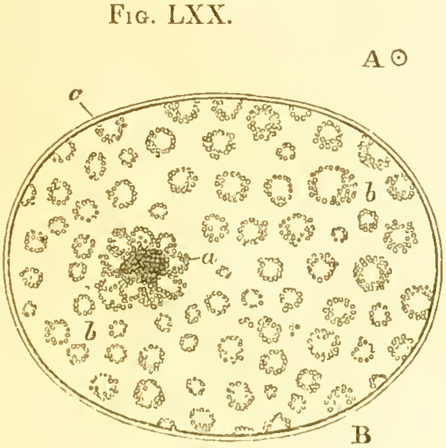


Fig. LXX. Ovum of the dog, from the uterus, but as yet unconnected with it, fourteen days after the first and eleven days after the second access of the male. *A*, the ovum of its natural size; *B*, the ovum seen under the lens. The rings of vitellary granules have disappeared; the dark granular mass *a*, the embryonic spot, has enlarged; *b*, the vitellus; *c*, the chorion, which has become comparatively much thinner, and probably from the imbibition of fluid appears at some considerable distance from the yolk.

to which the various stages in the development are referred is usually that of the last intercourse; but these, as has been already

they could have been cells, the investing membrane of which had been accidentally torn; for as soon as any true cell was ruptured, the included granules were immediately dispersed in the surrounding water. (Vide fig. LXIX. which gives a more highly magnified view of the cells of figure LXVIII.) We now approach the form described by you (*Beitr. z. Gesch. d. Zeug.* tab. I. fig. 8 and 9.) and others, of which I therefore only send the representation (fig. LXV and LXX.). As the ovum continues to grow continually by the absorption of fluid, the granular rings of the second inner covering, which is constantly becoming more conspicuous, separate more and more from one another, and the ovum assumes an oval form. Although the ovum has now attained its resting-place, still it is by no means firmly attached: at this stage the ovum is more readily detected and easily observed. I have paid the greatest attention to the granular cumulus; it unquestionably lies within the second envelope. Upon one occasion I thought I had detected the germinal vesicle in it, but I soon satisfied myself that this was not the case. The granular cumulus consists entirely of an aggregation of granules, which leave a depression in the middle, around which the mass is disposed like a wall. Vide fig. LXV. *A* and *B*, and fig. LXX. *A*, *B*. The former is an ovum fourteen days after the first intercourse known to me, eleven days after the last; *A* is the natural size, *B* the same object as seen under the simple lens; the granular rings have disappeared; in their stead, and within the inner envelope, under a power of 250 (fig. LXVI.), nothing but cells are seen, and these so closely set together that they mostly show as six-sided figures. In the centres of these cells there are small nuclei contained, and in addition and between them an irregular granular matter. Midway between them is the wall-like granular cumulus. The outer envelope of the ovum was extremely fine and delicate. I take it there can be no doubt but that this outer envelope is the attenuated much-distended zona pellucida of the ovarian ovum, which is now known under the name of the chorion. The inner covering is a product of development, but not, as it seems, by any apposition or coalition of the vitelline granules, for these are still present and conspicuous in the granular rings after the formation of the membrane. As it is in this that the granular cumulus is contained, from which the development of the embryo proceeds, it ought to be called the germ-vesicle—the later umbilical vesicle."—"When I place my earlier in contrast with these my later observations, I imagine the process of the formation of the cells to be as follows:—The yolk-granules first cluster into small globular masses (*nuclei*), which then become surrounded by a cell. With the growth of the cell the granules separate from each other, become grouped into concentric rings, and in their turn form the nuclei of new cells, until at length each yolk-globule becomes surrounded with a cell, and so the blastoderma is engendered, as in fig. LXV and LXVI. where each cell incloses a simple nucleus. In figures LXVIII and LXIX, the cells are still few in number, and consequently there are many granules in each cell; in fig. LXX. the cells are more numerous and the nuclear granules fewer; in figures LXV and LXVI. the cells are still more numerous, and each contains but a single nucleus. Were we to extend this process, the alterations observed in the form of the yolk would be perhaps found to be due to it; all the yolk-granules being inclosed first in

stated, are very variable. On the twelfth, or from that to the sixteenth day, the ovum, which, from its originally rounded, has already assumed an oval form, begins to be drawn out at both poles, and to appear somewhat pointed or lemon-shaped (fig. LXXI.); it is about three lines in length, and half as much in thickness; the external membrane, or chorion, is still smooth; the internal vesicle is oval, and in its middle presents a clear pear-

two, then in four, then in eight cells, and so on, until each at length comes to have its own cell, which coalescing with one another the blastoderma is produced as a preliminary to the appearance of the embryo. These cells are of various sizes; in figs. LXVIII. and LXIX. the greater number measured from the 0,0014 to the 0,0018 of a Paris inch; some, however, no more than the 0,0008 of a Paris inch." These excellent observations of Dr. Bischoff give a clear insight into the earliest formative relations of the germ, and with a few modifications may undoubtedly be applied to the germ of the bird (§ 47 and § 84, where the subject is the histological or structural development), and of the human ovum; they may be viewed as fruits of Schwann's discoveries in regard to the cellular structure of the tissues in both kingdoms of nature. [" In the ovum arrived in the uterus, a layer of vesicles makes its appearance on the whole of the inner surface of the membrane which now invests the yolk. The mulberry-like structure [the embryonic spot] (which had been formed by the successive evolution and aggregation of nucleated cells), then passes from the centre of the yolk to a certain part of that layer (the vesicles of the latter coalescing with those of the former, where the two sets are in contact, to form a membrane—the future amnion), and the interior of the mulberry-like structure is now seen to be occupied by a large vesicle containing a fluid and dark granules. In the centre of the fluid of this vesicle is a spherical body, composed of a substance having a finely-granulous appearance, and containing a cavity filled with a colourless and pellucid fluid. This hollow spherical body seems to be the true germ. The vesicle containing it disappears, and in its place is seen an elliptical depression filled with a pellucid fluid. In the centre of this depression is the germ, still presenting the appearance of a hollow sphere."—" The germ next separates into a central and peripheral portion, both of which, at first appearing granulous, are subsequently found to consist of vesicles. The central portion of the germ occupies the situation of the future brain. From the region, occupied by the germ, there issues a hollow process, which, enlarging, comes to line the inner surface of the ovum or membrane, that enters into the formation of the amnion, and that corresponds to the *serous lamina* of authors, the lining itself representing the incipient state of the subsequent *vascular lamina* of the umbilical vesicle, a lamina continuous with the structure which corresponds to the *area vasculosa* of authors on the bird. There does not occur in the mammiferous ovum any such phenomenon as the splitting of a germinal membrane into the so-called *serous*, *vascular*, and *mucous laminæ*. Nor is there any structure entitled to be denominated a *germinal membrane;* for it is not a previously existing membrane, which originates the germ, but it is the previously existing germ, which, by means of a hollow process, originates a structure, having the appearance of a membrane. From M. Barry. R. W.]

shaped space, the GERMINAL AREA (fig. LXXI. *B, c*), which is bounded externally by the vascular area, with its still large (and more conspicuous) granules; the PRIMITIVE STREAK or TRACE is at the same time discovered (fig. LXXI. *B, c*, fig. LXXII. *a*); a little later, in ova of four lines in length, which are completely lemon-shaped in their outline, the transparent germinal area is longer and more fiddle-shaped, the chorda dorsalis with the enlargement towards its cranial end, and the two laminæ dorsales, are all expressed; the dorsal laminæ unite first in the middle line of the future back, but before this happens the vertebral laminæ have made their appearance as four-cornered dark spots; this takes place on the seventeenth or eighteenth day, when the embryo is about two lines in length. After the coalition of the dorsal laminæ, the embryo, which lies with its long axis in the line of the transverse axis of the elongated ovum and uterus, begins to bend in upon itself, the head first, and then the tail tending downwards; at this epoch it is also becoming more and more distinct from the blastoderma, which has now grown around the whole yolk as an elongated bladder or vesicle, and separated gradually as the umbilical vesicle from the intestinal canal already in the course of evolution, but is still in free communication with the boat-shaped abdominal cavity of the embryo, and is covered with a very abundant network of vessels. At this time—about the twentieth day—the ovum (fig. LXXIII.) is ten lines in length, the embryo (fig. LXXIII. *a*) somewhat more than three. The chorion has pushed forth small cylindrical shaggy processes or villi, but it is still smooth and transparent at that part where the embryo lies

FIG. LXXI.

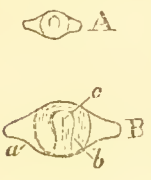


Fig. LXXI.—An ovum from a bitch the seventeenth day after the last access of the male; the chorion is seen already to present the figure of a lemon. *A*, the ovum of the natural size; *B*, the ovum slightly magnified; *a*, the chorion; *b*, vitellus, upon the surface of which, and appearing through the membranes, the pear-shaped area pellucida, and, unless I am mistaken, the nota primitiva or primary streak, *c*, are seen.

FIG. LXXII.

Fig. LXXII.—Ovum of the bitch, after Prevost and Dumas (*Ann. des Sc. Nat.* 1825, t. iii. tab. 5). The primary streak, or perhaps the chorda dorsalis, is perceived in the middle of the pyriform area pellucida, which is surrounded by the more egg-shaped area vasculosa.

under it upon the blastoderma and umbilical vesicle (fig. LXXIV. *A*), although at a later period it also produces villi in this situation; at both poles, however, it always remains smooth and without villi; the vessels are seen proceeding from the embryo to the blastoderma as the omphalo-mesenteric trunks (fig. LXXIV. *c, c, c*) and forming a rete or network upon the umbilical vesicle. The dorsal laminæ have coalesced through their entire length; posteriorly (fig. LXXIV. *B. d*) they still continue a little way apart, so that here a lancet-shaped space remains, as in the chick (fig. XXXVI. at *f*); the brain and spinal cord are formed, the former appearing divided into many vesicles or cells; the number of vertebral laminæ has increased; the eye and the ear are indicated. The abdominal laminæ have been sent off from the dorsal laminæ, and converge to effect the closure of the cavity of the body; three branchial fissures and the same number of arches are obvious (fig. LXXV. *b*,

Fig. LXXIII.

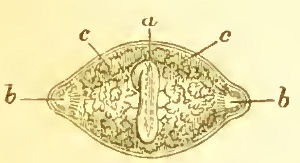


Fig. LXXIII.—Ovum of the bitch twenty-three days from the last access of the male. The chorion, *c, c*, has already shot forth little villi, which, however, are wanting at either end, *b, b*, of the ovum, and also over the place where the embryo is situated. Object of the natural size.

Fig. LXXIV.

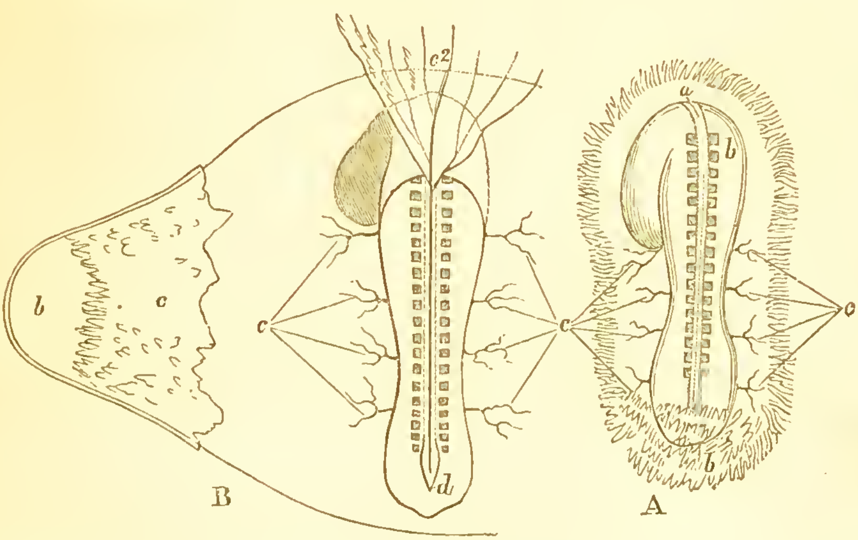


Fig. LXXIV.—*A* and *B*, magnified views of portions of the same ovum and embryo. *B*, c^2, is the chorion removed from the embryo and reflected upwards. *c, c, c, c, A* and *B*, the arteries of the germinal membrane; *a, A*, chorda dorsalis; *d, B*, inferior lancet-shaped extremity of the spinal marrow. Vide fig. XXXVI. and compare the embryo of the fowl with this.

fig. LXXVII. *c, c, c*); the upper layer of the serous lamina has been raised to form a cranial and caudal involucrum, and originates an amnion, which in the first instance surrounds the embryo very closely (fig. LXXVI.) as a serous envelope. The heart and vessels

Fig. LXXV.

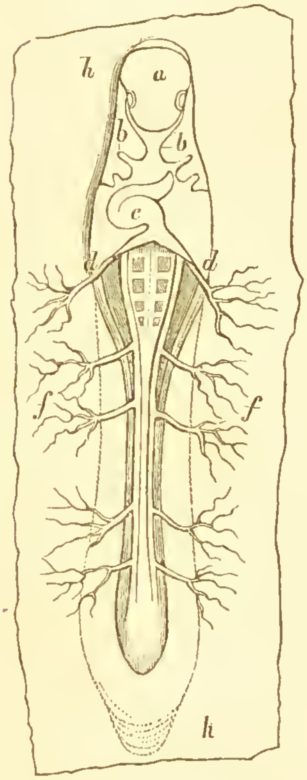


Fig. LXXV.—The same embryo still more highly magnified, and seen from the abdominal aspect: *a*, vertex; *b, b*, branchiæ; *c*, heart, appearing as a contorted pouch; *d, d*, veins of the germinal membrane; *f, f*, arteries of the same, springing from the two aortas; *h, h*, germinal membrane.

Fig. LXXVI.

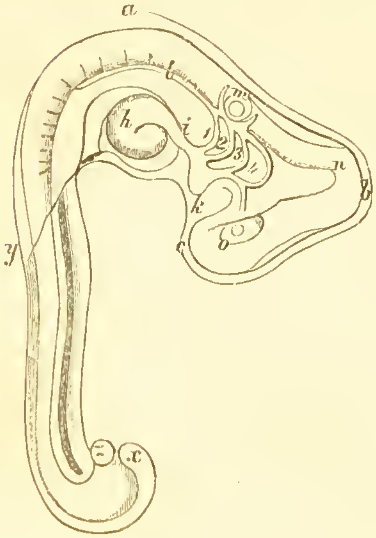


Fig. LXXVI.—Embryo of the dog of the third week, magnified; after Baer (*De Ovi Mammal. Genesi*, vii.): *a, b, c, y*, the amnion; at the curve of the tail, *x*, the allantois, *z*, is seen as a minute vesicle; *h*, the heart, from which springs the aorta, *i*, with its bulbous enlargement, *k*, from which arise the four arteries, of the branchial arches, 1, 2, 3, 4, that afterwards unite and form the abdominal aorta, *l*; *m*, the auditory organ; *n*, the corpora quadrigemina; *o*, the eye.

have now formed in the vascular lamina; the heart in the first instance appears as a twisted canal (fig. LXXVI. *h*, fig. LXXV. *c*, and fig. LXXVII. *d*); at the under side, where the future atrium is formed, it receives two omphalo-mesenteric veins (fig. LXXV. *d*, *d*), and in the situation of the future bulbus aortæ it divides into four vascular arches (fig. LXXVI. 1, 2, 3, 4) which first unite into the aorta, again divide, run down near the vertebral column, and give off transverse branches, the arteriæ omphalo-mesentericæ (fig. LXXV. *f*, *f*), which, with the corresponding veins of the same denomination, form a network over the surface of the blastoderma and umbilical vesicle. The allantois springs from the inferior end of the intestinal canal, in the shape of a little vesicle (fig. LXXVI. *z*). The yolk becomes more and more fluid every day within the umbilical vesicle, and contains numerous drops of oil. On the inner aspect of the uterus the vessels enlarge in size and increase in number, and an exudation ensues which acquires a membranous consistence; this is the decidua, which consists for the most part of epithelial cells, connected by means of an albuminous matter and vessels; into this lining, or covering, as the uterus or ovum is considered, the villi of the chorion shoot and grow. The allantois increases rapidly in size, soon grows around or encircles the whole embryo with the umbilical vesicle, carries two arteries from the aorta with it, and is composed of an external vascular, and an internal mucous layer; it is in contact with the chorion almost in the entire circumference of the ovum, with the exception of the two poles, which are without villi, and thus forms the endochorion, or inner layer of the chorion; its vessels also grow into the cylindrical villi, the blood of the arteries that penetrate these returning by corresponding veins, which collect into a trunk that terminates in the inferior vena cava; it is thus that the umbilical vessels are produced, when the particular vascular system of the germinal membrane and umbilical vesicle becomes obliterated.

Fig. LXXVII.

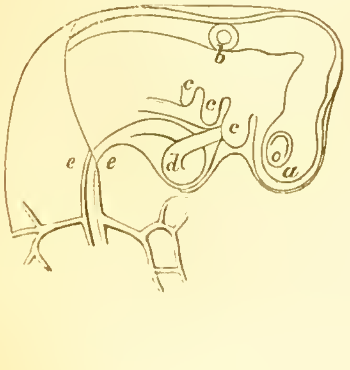


Fig. LXXVII.—Same embryo as in fig. LXXV. from the side: *a*, eye; *b*, ear; *c*, *c*, *c*, branchiæ; *d*, heart; *e*, *e*, trunk of the aorta Compare with this figure, that of Baer, fig. LXXVI., and those of the embryos of the fowl, already given (figs. LXXIII.—LXXV. and this, are after original drawings by Bischoff.)

A placenta—a mass formed of the decidua and the uterine vessels which grow into it on the one hand, and of the umbilical vessels of the embryo on the other, these two systems of vessels not communicating together, however,—surrounds the embryo, at a later period, in the form of a belt. The chorion soon gives way at both poles of the ovum, and the umbilical vesicle escapes through the rent, and forms a hernial sac on either side, so that the ovum now assumes a cylindrical shape. In the fourth week the branchial fissures are closed (fig. LXXVIII.), the extremities have budded as little flattened offsets from the abdominal laminæ (*n*, *o*); the heart (*a*) has now acquired its different parts; the intestine is drawn out towards the umbilical vesicle, as a fine continually decreasing and finally filiform canal (*g*); the lungs (*c*) and the liver (*d*), originally offsets from the intestine, have now become distinctly separated from it; the Wolffian bodies, or false kidneys (*k*, *k*), occupy the rest of the abdominal cavity lengthwise, and now appear as two symmetrical bodies placed on either side of the vertebral column; there is still no visible trace of the kidneys and sexual organs; the tail (*p*) is already well developed [139].

[139] The account of the development of the chick during the first five days (§ 49—§ 59), and the figures annexed, ought to be contrasted, step by step, with the details just given. In illustration of these the observations of Bischoff (vide his MS. explanations of figs. LXXIII. LXXIV. LXXV. and LXXVII. in notes to § 70), and the researches of Prevost and Dumas (*Ann. des Sc. Nat.* iii.), of Baer (*De Ovi Mam. et Hom. Gen. et Entwickelungsgeschichte*, ii. p. 213), of Gurlt (*Manual of Physiology of our Domestic Mammalia*, 1837), of Coste (*Embryogénie*, i. 395), of Bojanus (*in Nov. Act. Acad. Nat. Cur.* x. p. 141), and myself, are brought to a focus, as it were, and displayed in these figures (figs. LI. to LXXXIII.), the engravings being either from original drawings, or copied after the writers mentioned. These figures will, I trust, satisfactorily illustrate the very difficult

Fig. LXXVIII.

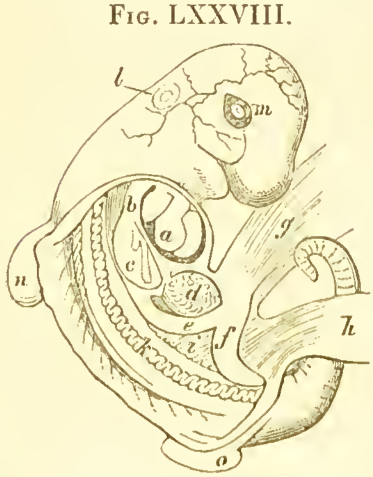


Fig. LXXVIII. — Embryo of the dog, after Coste (*Embryogénie comparée*, t. iv. f. 9), presumed to be twenty-four days old, magnified three times: *a*, heart; *b*, windpipe; *c*, lung; *d*, liver; *e*,*f*, the two portions of intestine which are in communication, at *g*, with the umbilical vesicle; *h*, allantois; *i*, mesentery; *k*, *k*, corpora Wolffiana; *n*, anterior extremity; *o*, posterior extremity.

points in the early stages of development among the mammalia. The form intermediate between those represented figs. LXV. and LXXI. appears to have been observed by Coste (*Embryogenie*, pl. vi. fig. 3), but his figure is not sufficiently decided, and is therefore not made use of. I have observed in the rabbit, that the germinal membrane becomes clearer at the dark spot—the embryonic spot, and first shows a round transparent germinal area. In the dog the ovum appears to pass very soon from the round or oval, into the ellipsoidal and lemon form; I observed it thus, for instance, in the ovum, represented fig. LXXI. (seventeenth day), in which the germinal area has already become pyriform, and the primitive streak appears to be formed. Prevost and Dumas represent the ovum of this period

Fig. LXXIX.

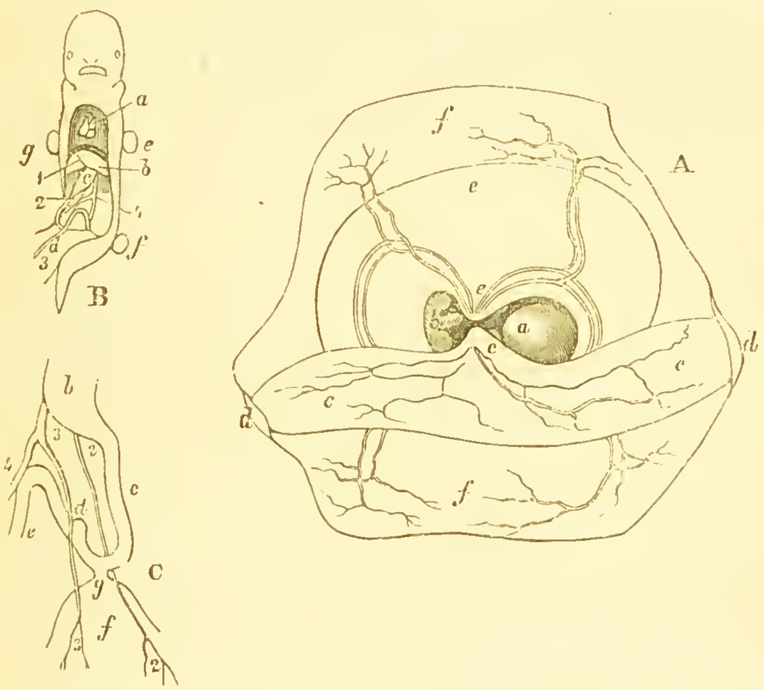


Fig. LXXIX.—Embryo of the dog still farther advanced, after Bojanus (*Nov. Act. Acad. Leopold.* &c. vol. x. p. 140). The embryo is presumed to be of the twenty-fourth day by the writer. *A*, the embryo included in the amnion; *a*, head; *b*, tail; *c*, *c*, *c*, the umbilical vesicle, become of great length, with its vessels; it is covered at its two extremities, *d*, *d*, by the chorion, *f*, *f*, which is laid open; *e*, *e*, allantois, with its vessels. *B*, the embryo of the natural size, from the abdominal aspect; *a*, heart; *b*, liver; *c*, stomach; *d*, stem or duct of the allantois, called brachus; *e*, *g*, anterior, *f*, posterior extremities; 1, diaphragm; 2, cepatic vein divided; 3, omphalo-mesenteric vein; 3, omphalo-mesenteric artery; 4, descending aorta. *C*, intestinal and omphalo-meseraic vessels, magnified; *b*, stomach; *c*, superior piece of intestine; *d*, cœcum; *e*, rectum; *f*, umbilical vesicle, communicating, at *g*, with the intestine; 2, omphalo-mesenteric vein; 3, omphalo-mesenteric artery, proceeding from the aorta, 4. Compare with this figure that of the human embryo of six weeks.

as pyriform (l. c. tab. v. fig. 4), as if one pole only had first been drawn out, a circumstance which I have never observed, and which is perhaps abnormal. The representation of the next stage in the development (fig. LXXII.) is copied from Prevost and Dumas; here the germinal area is already somewhat fiddle-shaped; I hold the streak here to be the chorda dorsalis. Then follow the figures from Bischoff, figs. LXXIII. LXXIV. LXXV. and LXXVII. the ovum being at this time in the twenty-third day. The embryo of about three weeks, given by Baer, in fig. vii. of his *De Ovi Mam. &c. Genesi* (copied in our fig. LXXVI.), is evidently very nearly at the same period of its evolution; the ovum, the figure of which, after Coste, is copied in our fig. LXXVIII. is certainly farther advanced; apparently it has reached the twenty-fourth day. We have next the very clear and carefully drawn figure of Bojanus, of an ovum and embryo of the dog of the twenty-fourth day, which is copied in our fig. LXXIX. *A, B, C.* For further illustration of the subject, and by way of comparison, I have added figures of the embryos of different animals to the close of this period, which may be assumed to correspond, as nearly as possible, to the first four weeks of the human embryo. Fig. LXXXI. is the embryo of a rabbit; fig. LXXXII. that of a sheep, after Coste. The two embryos of the mole, fig. LXXX. *A* and *B*, are about as far advanced as the most forward embryo of the dog given in fig. LXXIX. and

Fig. LXXX.

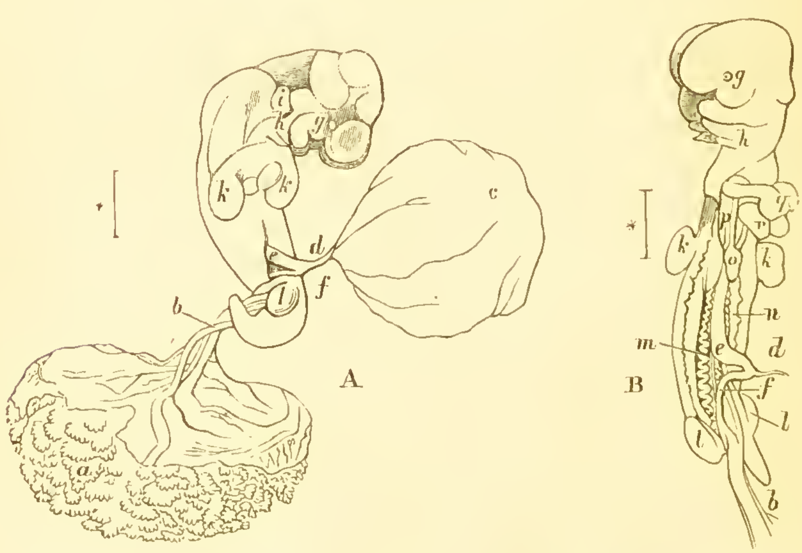


Fig. LXXX.—Embryo of the common mole (*Talpa Europæa*) three lines in length, drawn under the simple lens: *A*, the embryo entire; *B*, the embryo with the abdomen laid open; *a*, the chorion; *b*, pedicle of the allantois and umbilical vessels; *c*, umbilical vesicle and its duct; the omphalo-mesenteric duct, *d*; *e*, gastric portion of the intestine; *f*, intestinum rectum; *g*, the small but distinctly-marked eye; *h*, branchial arches disappearing; *i*, auditory vesicle; *k*, anterior, and, *l*, posterior extremity; *m*, Wolffian bodies of the left, *n*, of the right side; *o*, the still simple rudimentary lung sessile on the trachea, *p*; *q*, ventricle, and *r*, atrium of the heart. The several divisions of the brain, the nasal aperture, the mouth, &c. are depicted in *A*.

Researches on the human Embryo in the earliest periods.

§ 72. Good descriptions and representations of the human embryo, within the first month from conception, are very scarce [140];

the smallest human embryo, figs. LXXXIV. and LXXXV. In fig. LVII. the embryo of a lizard, with the branchial fissures closing, and the extremities budding forth, is given for the sake of comparison; the correspondence in point of appearance between the embryos of birds and mammalia of the same periods is very obvious.

[140] Among the many descriptions and figures that have been given of ova of the first month, I have scarcely met with one or two that seem calculated to convey correct ideas of the state of the development at this period. By much the clearest and most beautiful representations with which I am acquainted, are those given in figs. LXXXV. and LXXXVI., and referred to in the text as types of the development of the embryo at their respective periods,—the third and the fourth

Fig. LXXXI.

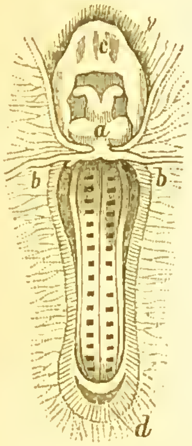


Fig. LXXXI.—Magnified embryo of the rabbit, after Coste (*Embryogénie*, pl. vii. fig. 4): the abdomen is still widely open, the vertebral column shining through; *a*, the heart, receiving the veins, *b*, *b*, of the germinal membrane; *c*, head; *d*, tail.

Fig. LXXXII.

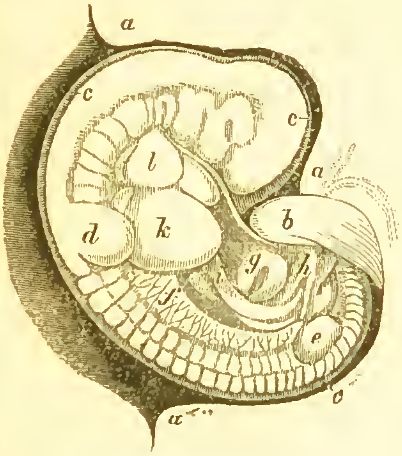


Fig. LXXXII.—Embryo of the sheep of the twenty-fourth day, magnified four diameters, after Coste (*Embryogénie*, pl. vii.): the allantois, *a*, *a*, *a*, is only represented as it arises; *b*, pedicle of the vesicula umbilicalis; *c*, *c*, *c*, amnion, still lying very close; *d*, fore, and *e*, hind extremity; *f*, Wolffian body; *g*, noose of intestine; *h*, pedicle of the allantois; *i*, the right vena umbilicalis; *k*, liver; *l*, heart.

N. B. These latter figures, from LXXIII. to LXXXII. are adapted for comparison with those of the human embryo, fig. LXXXIII. et sequent.

it is true indeed that we have many accounts of diseased ova, of monstrous or distorted embryos of this period; but instead of aiding

week. The smaller embryo, which measures but two lines in length (fig. LXXXIV. LXXXV. and LXXXV. *A*), was examined by me so long ago as 1831. The decidua surrounding the ovum presents itself as a bladder closed on every side (fig. LXXXIII.), and was perfectly normal, slightly shaggy externally, and without doubt had been connected by means of its villi with the uterus. The various details, which are given with the greatest fidelity in the figures, represent, as I conceive, the entirely normal development; the embryo, however, from its condition, must have died some short time before abortion took place. The anterior cerebral vesicles and the upper-jaw are proportionally somewhat too large; but these appear to be the only parts that are not thoroughly normal. Very similar to this embryo appears to be the one described by Müller in his *Archiv* for 1834; the ovum and embryo, however, were somewhat larger than mine; the chorion was between seven and eight lines, the embryo two lines and a half, in their long diameters. The umbilical vesicle, a line and a half in length, as in the embryo figured by me, also went quite wide over into the intestine, the place of the future pedicle being only indicated by a slight constriction; the amnion lay immediately and closely upon the embryo. According to Müller, this ovum was either *thirty-four* or *thirty-nine* days old; the latter he holds the more probable age; intercourse had taken place on the 2nd December,—on the 25th, the expected menstrual period was missed. On the 27th, intercourse again took place, and on the 5th of January the ovum was thrown off. I am firmly persuaded, along with Baer, *Entwickelungsgeschichte*, ii. 270, that this ovum was *twenty-one* days old,—from the 5th to the 27th of December, and that the second intercourse detached it. The fœtus described and figured by Müller, in Meckel's *Archiv* for 1830, tab. xi. fig. 11., is of singular beauty and quite normal. I have given a copy of this fœtus in fig. LXXXVI. *A*, of the natural size, *B*, enlarged, and in *C* have added a view of it still surrounded by its membranes, as these must have existed according to the laws of analogy and the numerous observations which I have made on other occasions. My object in this was for the sake of comparison with fig. LXXXV. *A*. All the older representations of embryos at this early period are valueless, partly from want of the requisite attention to detail, and partly from the defective state of knowledge in regard to the import of the several parts and their mutual relations.—Vide a list of such figures in Burdach, *Physiol.* ii. 449. Those of Soemmerring, Pockels, Kieser, Meckel, and Hunter, I regard as being from fœtuses that have either suffered from disease, or are actual monstrosities. By this, I do not mean to say that the study of such abnormal embryos is of no interest in a physiological point of view; on the contrary, many parts often exist quite normal in their formation, though others may be very much the reverse. Baer, for instance (*Entwickel.* ii.), has figured and described many embryos at an early period that are generally monsters; but the intimate knowledge of development possessed by this writer has enabled him to describe things correctly and according to the standard. The writer just quoted has some excellent observations on this subject in *Siebold's Journal*, xiv. 401, with plates. [The reader is further referred to a highly interesting paper by Dr. Allen Thomson, in which descriptions are given of three very early embryos examined by him, in the *Ed. Med. and Surg. Journal*, for

us or advancing our knowledge of the earlier periods of development in the human subject, these accounts are even generally calculated to mislead, and it is therefore well to regard the greater number of them as of no kind of value [141]. Some have said that they had found ova in the tubes, or on their very first entrance into the uterus, and before the separation of the embryo from the germinal membrane [142]; but all statements of this kind yet in existence are in the highest degree unsatisfactory. The smallest ova hitherto observed in the uterus, or thrown off by abortion, which in the present state of knowledge in regard to the history of development can be allowed to be normal in their formation, or even as departing but a little from the rule, have been about three weeks old. Such ova, still surrounded by the decidua (figs. LXXXIII. LXXXIV.

July, 1839. R. B. T. And to an account of a human ovum described by T. Wharton Jones (*Philos. Trans.* 1837), which is probably the earliest that has yet been seen; certainly earlier than either three or four weeks, the period which Mr. Jones, following Dr. M'Kenzie, assigned to it. R. W.]

[141] The subject of diseased ova and malformed embryos will be taken up farther on in this work. Meantime, I may say, that after much inquiry I find an effusion of blood into the decidua, on the formation of the reflexa and serotina, to be the primary cause of the death of the embryo in the majority of cases. When this has occurred, ova may still go on increasing for some considerable time, as Meckel remarked, though the embryo makes no further progress;—a fact which accounts for the usual immense disproportion in aborted ova between the size of the envelopes and the little misshapen and sometimes totally wanting embryo. Velpeau has given a collection, and in this point of view a very interesting collection of figures of monstrous ova and embryos.—*Embryologie Humaine*, Paris, 1832. But the views which he and many others have adopted from the study of such abortions, in regard to the allantois, the formation of the amnion, &c., are altogether erroneous.

[142] The well-known accounts which we have from Home and Bauer and others, of ova found in the tubes, or at an extremely early period in the uterus, and which Coste has lately referred to and used with so much confidence, I hold to be so uncertain that they are altogether without value to science. The early embryos and ova described by Pockels (*Isis*, 1825), I also believe to be so much altered and so abnormal that they can only be used with the greatest reserve.

FIG. LXXXIII.

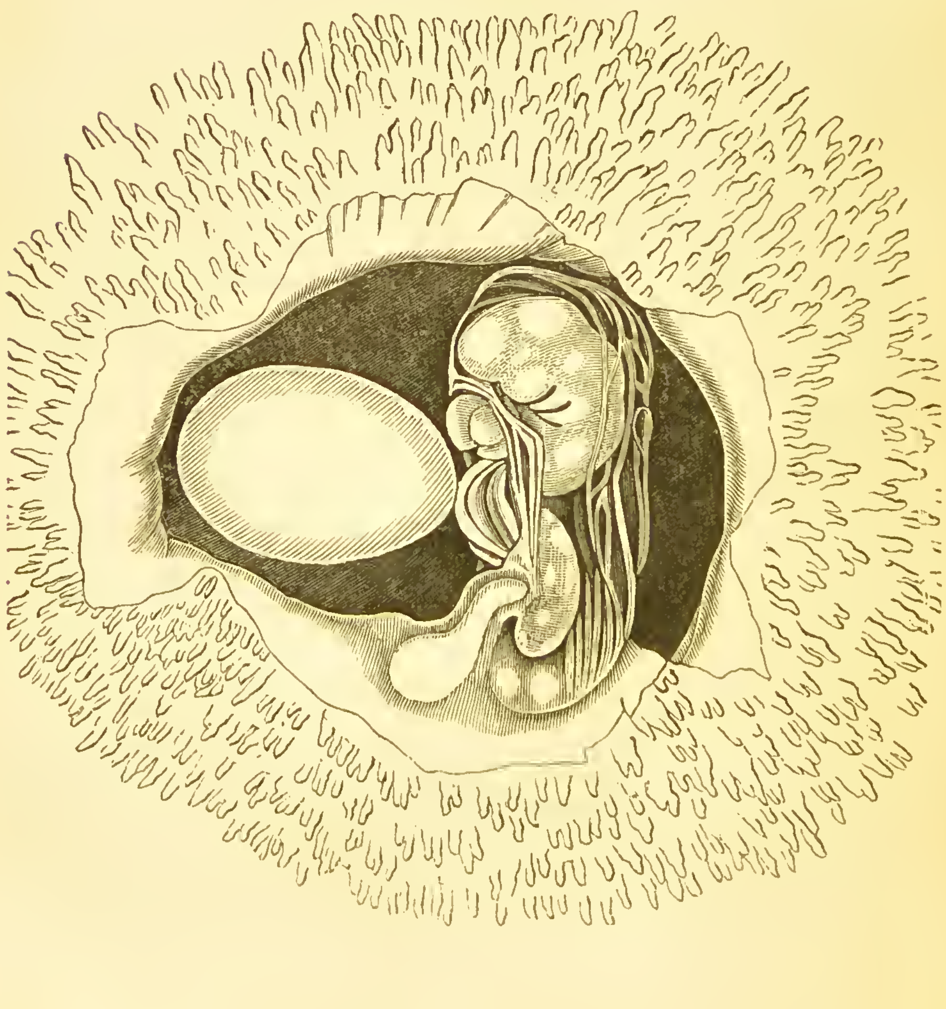
Fig. LXXXIII.—A perfectly normal human ovum of the third week (about twenty-one days old), enclosed in the decidua. Size of nature.

and LXXXV. *A, B*), measure about seven lines in length; in the naked chorion they are about five lines long. The chorion at this time is beset externally with small cylindrical, hollow villi, which either do not penetrate the decidua at all, or do so to a very trifling extent. The embryo itself is two lines long (fig. LXXXIV. the natural size, fig. LXXXV. magnified, fig. LXXXV. *A*, with references, and *B*, cross-lines to indicate the natural size). It is plainly surrounded by an amnion (fig. LXXXV. *A, c*), which lies loosely but still pretty closely about it, and obviously proceeds from the abdominal laminæ. The embryo is curved (in the figure it is re-

Fig. XXXIV.

Fig. LXXXIV.—The same ovum laid open; the embryo, about two lines long, closely surrounded by the amnion, is seen through the division in the chorion.

Fig. LXXXV.



presented as brought forward from or out of the amnion); and presents anterior cerebral vesicles or hemispheres (k^1) pretty well developed (in the embryo figured they are perhaps abnormally large), and considerable corpora quadrigemina (k^2) immediately behind them; there is the distinct appearance of an eye (r), and a rounded offset from the medulla oblongata indicates the acoustic vesicle (i); several branchial arches and fissures are also conspicuous, the last of them, however, not yet completely formed. (In the embryo here particularly referred to for example, the oral aperture may be observed before the lower jaw (h), followed by two branchial fissures; the third branchial arch succeeding the last of the fissures is not yet completely detached.) The anterior (l) and the posterior (m) extremities are curved leaf-like processes, still of

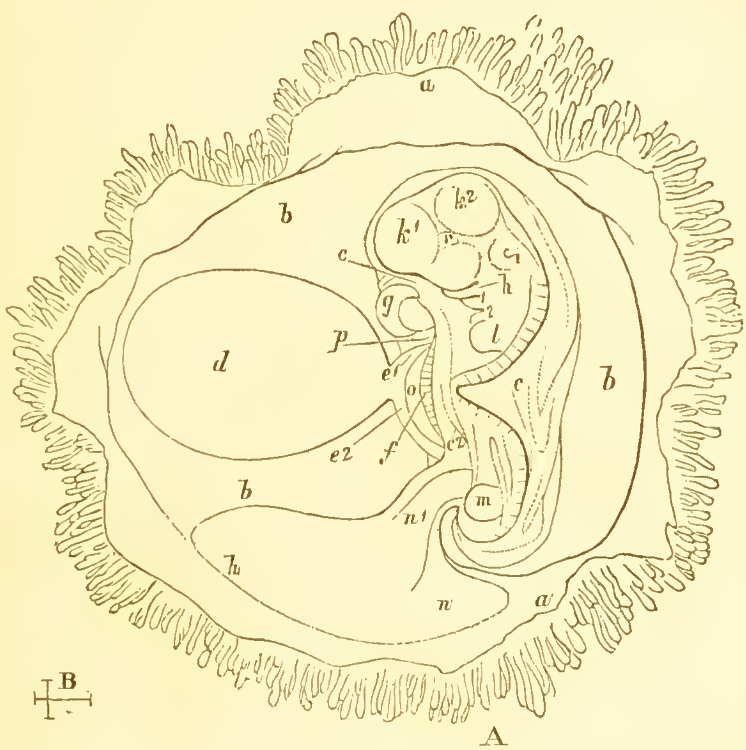


Fig. LXXXV.—The same same ovum magnified; the whole of the parts designed from nature.—*a, a,* Chorion laid open and reflected; *b, b, b,* albuminous space betwixt the amnion and chorion; *c,* amnion, which is still open from c^1, in front, to c^2, behind; *d,* umbilical vesicle, communicating with e^1, the ventricular intestine, and e^2, the rectum; *f,* corpora Wolffiana; *g,* heart; *h,* lower jaw; *i,* ear; k^1, hemispheres; k^2, corpora quadrigemina; *l,* anterior, and *m,* posterior extremity; *n, n,* presumed limits of the lamina vasculosa of the allantois; 2^1, lamina mucosa of the allantois; *o,* mesentery; *p,* liver; *r,* eye; 1, 2, two branchial fissures.

very small dimensions. The anterior aspect of the embryo is occupied by the abdomen, at this time a long and pretty wide cleft (from c^1 to c^2), and still completely open, from which the amnion is reflected as the cranial and caudal involucra. In this cleft, but projecting beyond it in the form of a hernia, lies the heart (g), already of very large relative dimensions, and consisting of a simple atrium, or auricle and ventricle; behind the heart is seen the liver (p); and under the liver the intestine, which is attached by means of a distinct mesentery (o). At the part where the small intestine (e^1) and the large intestine (e^2) meet, the canal makes an extensive sweep in the umbilical vesicle (d), which is now not much less in size than the entire embryo. On either side of the lamina mesenterica and in contact with the vertebral column a narrow elongated body (f) is observed, which exhibits various constrictions, and is composed of short cœca; this is the Wolffian body or primordial kidney. From the lower extremity of the intestine a hollow sac or bladder (n^1), which attaches itself to the chorion (a, a), and coalesces with its inner surface, is seen protruding: this is the allantois, which presents itself as a broad, flat, well-defined bladder, the limits of which (h—n) may often be distinguished on the chorion; here therefore the chorion is also split into two laminæ, of which the inner lamina, or *endochorion*, is smooth, the outer, or *exochorion*, villous. The embryo together with the amnion and umbilical vesicle do not occupy the entire cavity of the chorion; there still remains a considerable space (b, b), which is filled with a delicate filamentous or arachnoidal tissue, occasionally also with an albuminous fluid, or a fluid that strongly resembles the vitreous humour of the eye.

Embryos of the fourth week (fig. LXXXVI. *A*, natural size, *B*, moderately, *C*, highly magnified, and with references to the several parts,) are about three lines and a half in length. The amnion (c) now surrounds the embryo as a capacious envelope, and has become closed in front. The corpora quadrigemina (k^2) still form the largest mass of the brain; in front of them lie the hemispheres (k^1); and behind them the cerebellum (k^3). From the medulla oblongata the process for the organ of hearing (i) projects conspicuously. In the eye (r), the lens is now obvious, and surrounded by the choroid. Behind the lower jaw (h) there are now three branchial fissures and three branchial arches, the most posterior of which is not yet fully detached along its hinder margin from the lamina abdominalis. The anterior and posterior extremities (l, m), have increased in size, and form rounded and

already in some slight degree detached leaflets. The heart (*g*) and liver (*p*) are of considerable magnitude; the intestine (*e*) rises in

Fig. LXXXVI.

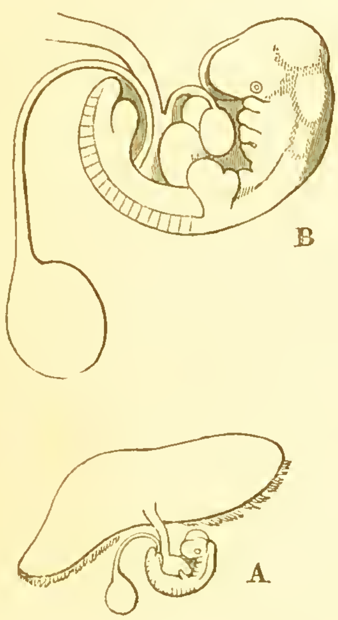
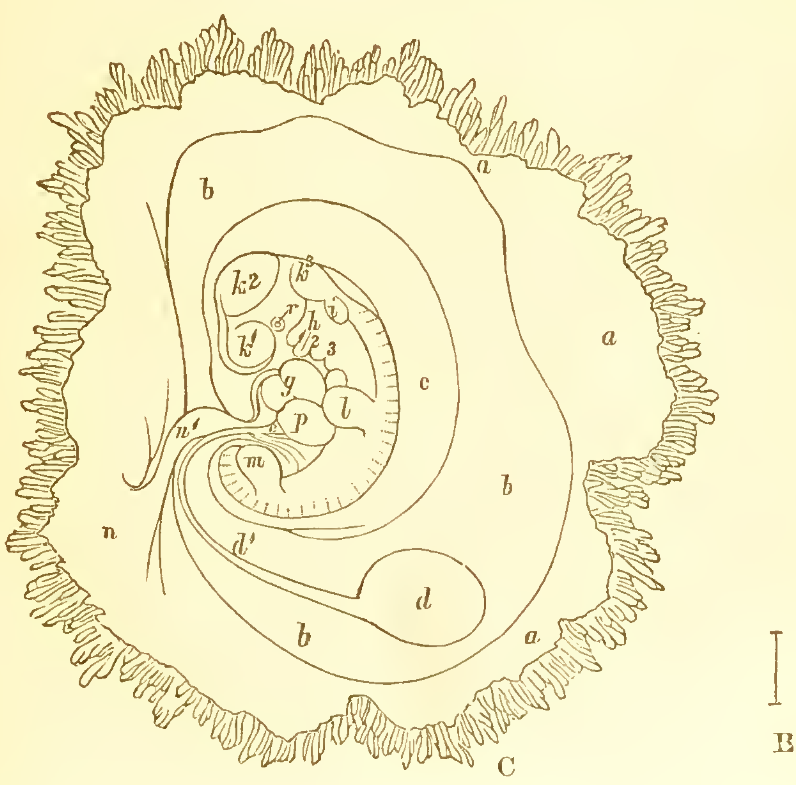


Fig. LXXXVI. — A very beautiful embryo figured and described by Jo. Müller, in Meckel's *Archiv*, 1830, tab. xi. *A*, natural size. *B*, magnified view. *C*, view still more highly magnified, with the membranes restored, and references to the several parts. I regard it as about twenty-eight days old. (The references are mostly the same as in the last figure.) *a*, *a*, Chorion laid open and reflected; *b*, *b*, *b*, albuminous space betwixt the amnion and chorion; *c*, amnion; *d*, umbilical vesicle; d^1, pedicle of the umbilical vesicle; *e*, noose of intestine communicating with d^1; *g*, heart; *h*, lower jaw; *i*, ear: *k*, cerebellum; k^1, hemispheres; k^2, corpora quadrigemina; *l*, anterior, and *m*, posterior, extremity; *n*, point where the allantois and chorion have coalesced; n^1, umbilical cord; *p*, liver; *r*, eye; 1, 2, 3, branchial fissures.



sharper loops from the abdomen, and the umbilical vesicle (d) is lengthened out into a long, hollow, filiform pedicle (d')—the ductus omphalo-mesentericus; the canal of the allantois (n') has also become longer and narrower, but still expands in the form of a funnel (n) towards the chorion (a). The chorion internally is smooth; externally the cylindrical short villi with which it is covered have begun to divide, and push forth lateral branches. The space (b, b) between the chorion and amnion is still considerable, and filled with the arachnoidal tissue, amid which lies the umbilical vesicle (d). In embryos of the third and fourth week, the divisions of the vertebræ are very distinctly marked (as in figs. LXXIII. and LXXIV.) along the posterior aspect, and the caudal vertebræ (ossa coccygis) and forehead are brought close to one another in consequence of the curvature of the embryo. From the account now given, it is obvious that the human embryo of this period bears the greatest resemblance to that of other mammalia both in its general external characters and in the form of its particular internal organs [143].

Human Embryos of the second month.

§ 73. The number of descriptions which we possess of normal human embryos of the second month, when the growth is extremely rapid, is much more considerable. The amnion is now widely separated from the embryo, which it surrounds as a capacious bladder; it incloses the embryo anteriorly, and, investing the pedicle of the allantois and umbilical vesicle, forms the umbilical cord, which connects the embryo with the allantois, and even now is often of greater length than the embryo itself. The villi of the chorion in-

[143] Vide the various delineations of the embryos of mammalia in figs. LXXVI. LXXX. LXXXI. and LXXXII., especially that of the mole, fig. LXXX. *A* and *B*, and also the different ova of the dog, in figs LXXIII. et seq.

Fig. LXXXVII.

Fig. LXXXVII. — Chorion of an ovum of the sixth week. At a appears the part which is almost without villi, and which, with the progressive evolution, becomes ever larger and larger; so that the villi seem to collect towards a particular district, and there form the placenta.

crease very rapidly, divide, like a tree, into branches and twigs, which terminate at length in rounded leaflets (fig. LXXXVII.); the villi strike into the decidua, and in one part in particular they are much more numerous and closely set than elsewhere. In the fifth week the embryo, when stretched out, is from five to six lines in length (fig. LXXXVIII. fig. LXXXIX. magnified fig. XC.

Fig. LXXXVIII.

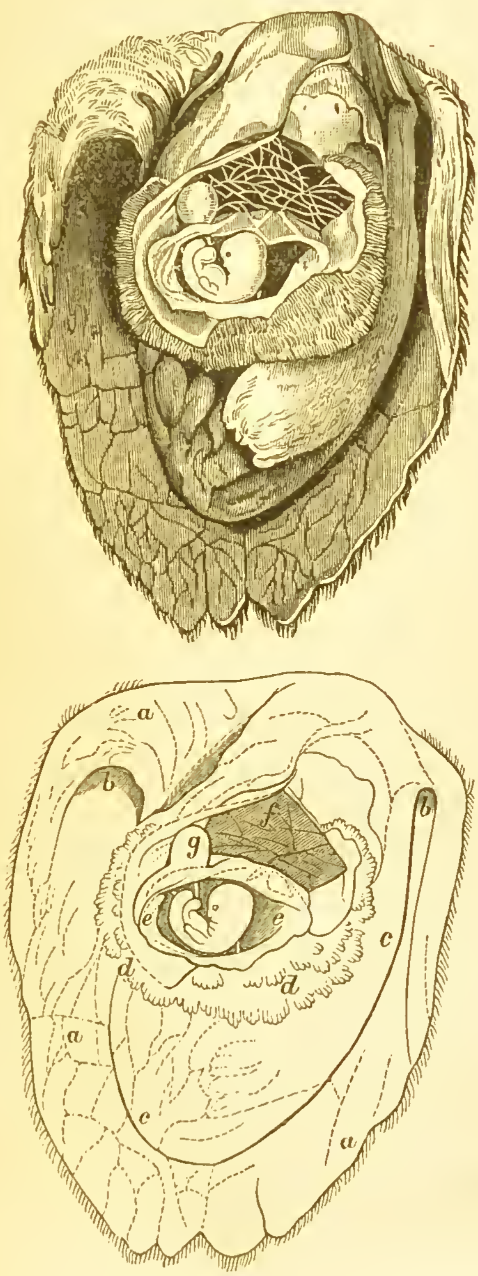


Fig. LXXXVIII. — Aborted ovum, in which all the parts are normal except the decidua reflexa. The decidua vera, *a, a, a,* is seen passing over into the decidua reflexa, *c, c,* which is infiltrated with blood, and much thicker than proper, at the points, *b, b*; *d,* villi of the chorion; *e,* amnion; *f,* a spider's web-like tissue, rendered darker by the action of alcohol in the albuminous interspace; *g,* the umbilical vesicle.

A); the extremities are larger, and project more; behind the terminal rounded hand-shaped portion, a second appears; the head is considerable, the cranial portion in particular still greatly elevated; the corpora quadrigemina run level towards the forehead; the hemispheres are still small; the eyes advance from the sides more forwards; the choroidea resembles a dark ring, broken in its circumference inferiorly and anteriorly (fig. XC. *B*); the nostrils appear as depressions upon the flat face; the branchial fissures are for the most part completely closed, but indications of their presence still continue long after their closure, in the sulci betwixt the former branchial arches (figs. LXXXIX. and XC.). The oral cleft is extensive and gaping; the os coccygis shows itself as a considerable tail bent forwards, and the vertebral incisures are very conspicuous towards the lower part of the vertebral column. The abdomen is closed, with the exception of the umbilical aperture, through which the elongated intestinal loop still passes outwards and inwards, included within the umbilical cord, and in communi-

Fig. LXXXIX.

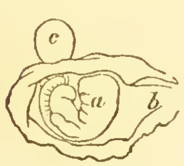


Fig. LXXXIX.—Embryo, *a* (of five weeks) of the ovum delineated in the preceding figure, contained in its amnion, *b*, which is laid open, with its umbilical vesicle, *c*.

Fig. XC.

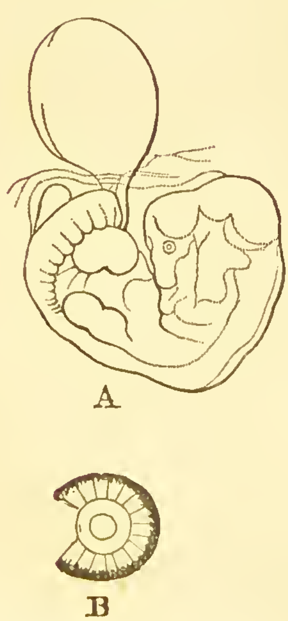


Fig. XC.—*A*, the same embryo as in fig. LXXXVIII. magnified; the brain and spinal marrow are seen shining through the superimposed structures. The corpora quadrigemina are still of large relative size; the nasal fossæ present themselves in front of the eye, in which a vast choroidal cleft is conspicuous. Indications of the second and third branchial clefts are still to be remarked; the umbilical vesicle has a shorter pedicle than in fig. LXXXVI. *B*, is the eye greatly magnified, to show the cleft in the choroid.

cation with the umbilical vesicle, through the medium of its duct, which is continually becoming finer and finer. In the sixth week the embryo is about seven lines in length; its external parts are the same, in general appearance, as in the sixth week (figs. XCI. and XCII.); the forehead, in consequence of the greater development of the hemispheres, is now more vaulted, though the cranium still advances greatly; all traces of the branchial fissures have disappeared, except perhaps a slight cicatrice in the situation of the second posteriorly, and by the boundary of the lower jaw (fig. XC. *i*), and in the situation where the Eustachian tube has been formed. Embryos of this period are easily opened and prepared, and present the various organs in their respective situations, and even with their permanent forms, in the most beautiful manner. (figs. XCI. XCII. and XCIII.). The spinal cord (fig. XC.) is

Fig. XCI.

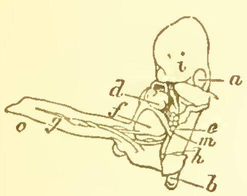


Fig. XCI.—An embryo of the sixth week in outline, of the natural size: *a*, anterior, *b*, posterior extremity; *c*, umbilical cord divided; *d*, heart, with its two distinct atria; *e*, lung of the left side; *f*, left lobe of the liver, at the under edge of which the stomach is situated; *g*, filiform vitello-intestinal duct, entering the protruding loop of intestine; *h*, corpora Wolffiana, and excretory duct of the sexual parts; *i*, sulcus, the remains of the first branchial fissure, which is transformed into the Eustachian tube.

Fig. XCII.

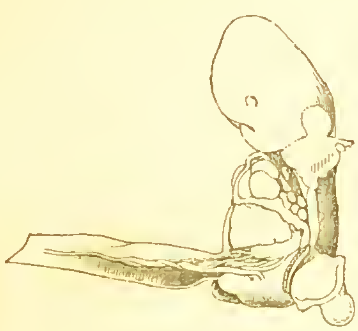


Fig. XCII.—The same embryo depicted of double the size, and with its several parts made out.

Fig. XCIII.

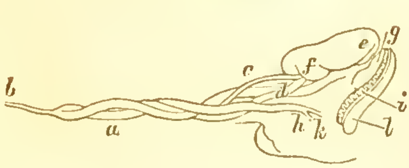


Fig. XCIII.—The abdominal viscera of an embryo magnified four times: *a*, intestinal loop situated in the umbilical cord; *b*, omphalo-mesenteric duct; *c*, omphalo-mesenteric vein; *d*, artery; *e*, stomach; *f*, rudiment of the germinal omentum; *g*, germ-preparing genital organ (testis or ovary); *i*, Wolffian body, with its very delicate excretory duct, which is torn across at *k*, and terminating in the cloaca, *h*; *l*, rudiments of the excretory duct of the germ-preparing sexual organ (vas deferens, or Fallopian tube).

cylindrical, of nearly uniform thickness throughout, and reaches to the coccyx, where it terminates in a blunt extremity; posteriorly, it is open and canalicular. The medulla oblongata makes a bend forwards at the top of the neck, and then ascends perpendicularly into the capacious cranium, where the corpora quadrigemina present themselves as two large semi-globular masses, having behind them a pair of narrow lateral and superiorly yet unconnected laminæ, the rudiments of the cerebellum. The medullary stem, or crus cerebri, passes under the corpora quadrigemina, and again bending downwards, the ganglia of the brain (the optic thalamus and corpus striatum) are evolved upon it in its course, these being covered anteriorly and superiorly by the hemispheres of the brain proper, which in the human embryo acquire a large size at a very early period: these parts, of course, are to be understood as developed in pairs. The first points of ossification appear in the seventh week in the clavicle and lower jaw; the vertebral arches are not yet closed in; the ribs lie on either side of the rudiments of the bodies of the vertebræ as narrow streaks. Rudiments of muscles are not yet distinctly visible, save perhaps in the diaphragm (fig. XCI. *m*), which presents itself, at a very early period, as a thick membranous septum, dividing the thorax and abdomen completely from one another. The heart (fig. XCI. *d*) is already turned leftward; the ventricle is still single, but the septum has begun to be formed; the atria show their separation from the ventricular cavity externally, but internally they still communicate freely (fig. XCIV.); the aorta and pulmonary artery (fig. XCIV. *a*) still arise as a common trunk, which divides into two vascular arches (*b*, *b*), which, however, come together again behind the diaphragm, and there form the aorta descendens (fig. XCV. *h*); the pericardium is complete, and forms a delicate envelope; the lungs lie on either side of the heart, in the angle formed inferiorly between the dia-

Fig. XCIV.

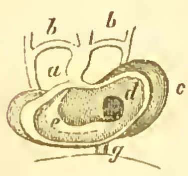


Fig. XCIV.—The heart of an embryo of about the fifth week, laid open upon the abdominal aspect. A very beautiful view is obtained of the manner in which the simple ventricle becomes divided into two separate chambers. The atrium cordis, *c*, still almost quite simple, is pushed backwards; at *d*, the passage from the atrium into the open ventricle is seen; the septum, *e*, resembling a fold of the inner membrane, is perceived rising towards the bulbus aortæ, *a*, which still affords a common origin to the aorta and pulmonary artery; from the bulb arise the two vascular arches, which unite to form the aorta; *g*, vena cava inferior. Figure after Baer, in Siebold's *Journal*, B. xiv.

phragm and the walls of the thorax, and do not yet receive any particular vessels (fig. XCI. *e*): they are mere sacs, not more than about one line in length, but already exhibit traces of division into several rounded vesicles or lobes; they hang by the rudiments of the trachea, a delicate thread, which shows a trifling enlargement superiorly, in the situation of the future larynx. The liver is very large (fig. XCI. *f*), divided into two lobes, and composed of small hollow granules, or cœca. Under the left lobe of the liver (*f*), the stomach (*e*) is observed of an elongated form, and even now transversely situated; from the part that will become its greater curvature, the omentum majus is seen springing as a very minute appendage or lappet, not above a quarter of a line in breadth; the intestine still shows itself as a long and somewhat twisted loop, extending far into the umbilical cord (*a*); the duct of the umbilical vesicle is obliterated, but its remains, in the shape of a fine thread (fig. XCI. *g*, fig. XCIII. *b*) can still be followed to the umbilical vesicle, now situated at a great distance from the body of the embryo; the anus is still imperforate. The corpora Wolffiana are now the only organs situated on the vertebral column. It is in the course of the seventh week that the kidneys and renal capsules first make their appearance, and they are speedily followed by the evolution of the germ-preparing sexual organs—the testicles and ovaria, which show themselves primarily as small long-shaped bodies. The urinary bladder does not appear before the end of the second month; it forms a slight mesial enlargement, which is continued superiorly and anteriorly as a hollow canal—the urachus—into the umbilical cord. In the seventh week the embryo is nine lines in length (fig. XCVI. *l*, fig. XCVII.). The head is of considerable size, and now fairly rounded off; the corpora quadrigemina, hitherto so largely developed, begin to take the subordinate place in point of size which belongs to them in maturity (fig. XCVII.); the eyelids begin to appear, first as perfectly circular, and by and by as oval folds, over the eye-

FIG. XCV.

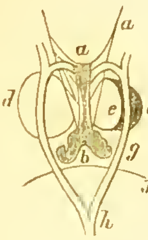


Fig. XCV.—The same heart as in the preceding figure opened from behind. The great atrium, *d, e*, is seen, and only the point of the ventricle, at *c*, to the right. The trachea, *a, b*, divides and ends inferiorly in the two very small lungs; the aortal arches, *g*, only unite at length in *h*, under the diaphragm *f*, to form the trunk of the aorta; at *a* the nervus vagus is observed.

balls; the anterior breach in the choroid coat is closed; in the ear the concha is formed, with its various eminences and depressions (fig. XCVII. *A*, *e*, and *B*); the mouth is a large triangular space, with one of the angles directed upwards, which still communicates with the future nasal cavity, and occupies nearly the entire breadth

Fig. XCVI.

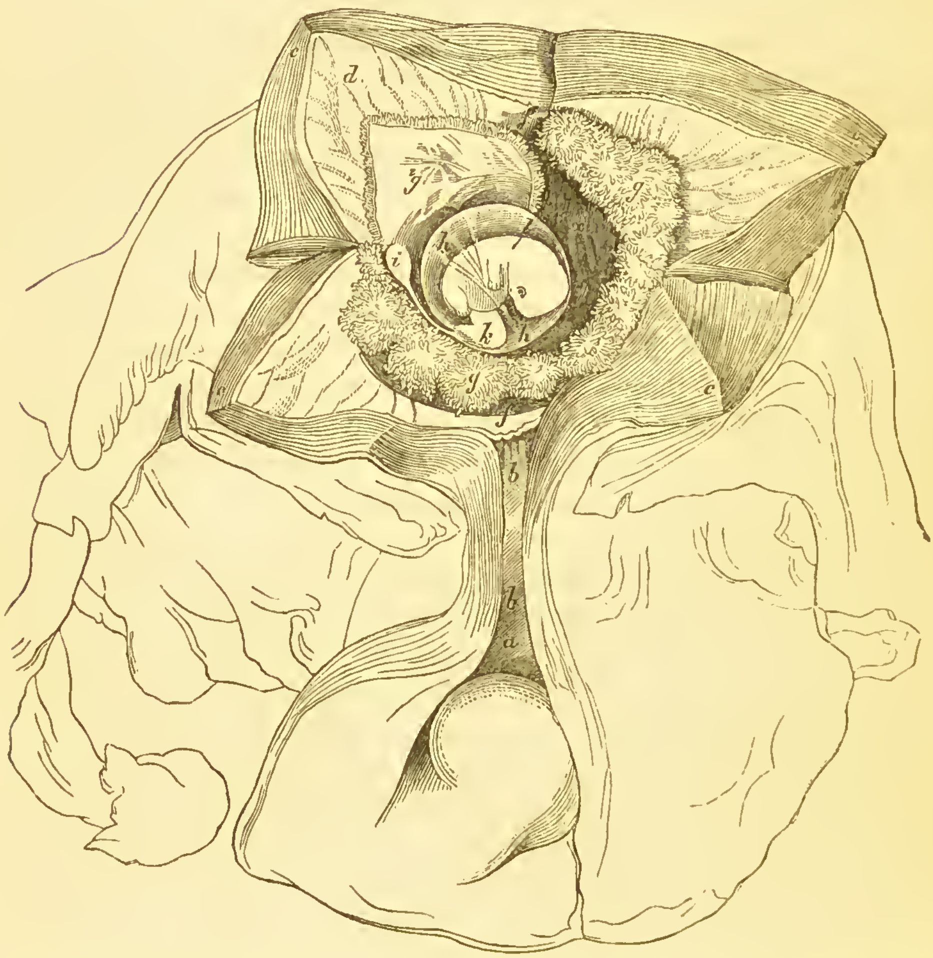


Fig. XCVI.—Uterus, with its contents, in the seventh week of pregnancy: the woman had committed suicide. The embryo, perfectly normal in its conformation, is enclosed in its amnion; betwixt the amnion and chorion the umbilical vesicle is seen; the uterus, lined with the decidua, is laid open, and its parietes are reflected so as to show its contents: *a*, the os externum; *b*, *b*, cervix uteri; *c*, *c*, *c*, *c*, the uterus laid open by a crucial incision, and reflected in four flaps; *d*, *d*, *d*, decidua vera, spread over the uterine surface; *g*, flocculi, or villi of the chorion; g^2, internal aspect of the chorion; *h*, amnion; *i*, umbilical vesicle; *k*, umbilical cord; *l*, embryo; *x*, space for the tunica media, as it is termed, betwixt the amnion and chorion. [The embryo is depicted of its natural size in fig. XCVII. Here the parts are but two thirds the size of nature.]

of the face; the nostrils are two depressions, or pits, with a broad septum interposed between them; the external nose already forms a slight projection (fig. XCVII.). The abdomen appears distended; the parietes of the trunk are still extremely thin. The extremities are more advanced; on the upper extremity the hand, with the rudiments of its five fingers (fig. XCVII. *C*) may be distinguished; the division into arm and forearm is also slightly indicated; the lower extremity is somewhat less forward in its development (fig. XCVII. *D*); still the various divisions of the member can be made out, and even the toes are slightly indicated.

All the particulars just mentioned become still more obvious in embryos of the eighth week (fig. XCVIII. the representation of an embryo, normal in every respect, except an umbilical hernia, *b*, which exhibits many points very beautifully); the head is now relatively larger; the lips begin to be formed; but the tongue, as formerly, lies uncovered in the bottom of the oral cavity; the fingers and toes begin to be distinctly pinched off from the rest of the hands and feet. The embryo is from ten to twelve lines in length, and over a dram in weight; the intestine is now completely retracted into the cavity of the abdomen, and the umbilical cord (cut off at *a*, fig. XCVIII.) is relatively thinner [144].

[144] We have good representations of the embryo during this period; the oldest

Fig. XCVII.

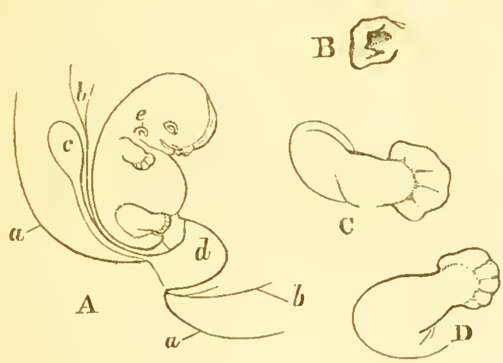


Fig. XCVII. — Embryo from the uterus delineated in the preceding figure: *A*, natural size; *a*, *a*, limits of the chorion; *b*, *b*, limits of the amnion; *c*, umbilical vesicle; *d*, umbilical cord; *e*, external ear. *B*, external ear magnified. *C*, anterior extremity magnified. *D*, posterior extremity magnified.

Fig. XCVIII.

Fig. XCVIII.—Embryo of the eighth week: *a*, umbilical cord cut; *b*, an umbilical hernia; *c*, the ear.

The human Embryo from the beginning of the third month to the period of birth.

§ 74. The particulars that still remain in regard to the development of the human embryo possess a degree of physiological interest much inferior to those we have hitherto related, and their especial consideration belongs to the morphology. It is generally believed that it is in the course of the third month, when the placenta is completely formed, that several considerable and even very important organs first make their appearance; these, however, are most probably present in a rudimentary state during the second month, but are overlooked. The chief of the organs that now become distinctly visible are the thymus, the spleen, the salivary glands, and the pancreas, the muscles, the nerves, the internal parts of the ear, and the ossicula auditus. In the course of the third and fourth months, moreover, we remark a continued progressive formation and transformation of the organs already present in their rudiments, consisting now in a closer approximation to the forms they are to possess permanently after birth, and again in a greater perfection of the forms peculiar to the fœtal state. To the latter head belong the formation of the membrana pupillaris in the third month; the gluing together of the eye-lids first, and then their complete coalescence along their margins, at the beginning of the fourth month; the rapid growth of the capsulæ suprarenales (figs. XCIX. and C. *n*, *n*), which, in the first half of the third month, are as large again as the imperfectly formed kidneys, that consist, at this time, of an aggregation of

by Albinus (*Annot. Academ.* lib. i. tab. i. fig. 12), and then by Soemmerring, Meckel, Burdach, Müller, Kieser, Mayer, &c. I have given new, and, I trust, satisfactory figures of embryos of the fifth, sixth, seventh, and eighth weeks.

Fig. XCIX.

Fig. XCIX.—Embryo of the tenth week, of the natural size, laid open along the abdomen, and the liver and intestine taken away.

three or four little lobules (fig. C. *o*), but which, immediately afterwards begin to diminish, like others of the fœtal organs, particularly the Wolffian bodies, which shrink greatly (fig. C. *s*, *s*) during this period, and finally disappear entirely, although remains of them, especially in the female sex, continue to exist till after birth. In opposition to this decrement of certain organs, the formative energy is aroused to great activity in others, which have remained very much behind in their development; the kidneys, which have hitherto been extremely small, consist, at the end of the third month, of seven or eight lobes, representing the future pyramida Malpighii; the ureters still terminate in common with the external ducts of the sexual organs and Wolffian bodies, and the rectum, in the cloaca or sinus urogenitalis; the rectum is the part which is first detached, and terminates peculiarly in the anus. The most remarkable of the transformations that take place, perhaps, are those connected with the generative organs, for it is at this time that the rudiments of the germ-preparing parts are transformed into testicles or ovaria, and their excretory ducts become vasa deferentia, or Fallopian tubes; that the uterus detaches itself from the upper part of the sinus uro-geni-

Fig. C.

Fig. C. — The same embryo magnified twice; *a*, palatine fissure; *b*, tongue; *c*, carotid of the right side; *d*, *d*, thyroid body; *e*, *e*, thymus gland; *f*, right ventricle, separated by a contraction from the left, *g*; *h*, right, *i*, left atrium cordis; *k*, right lung; *l*, *l*, diaphragm, still very membranous, and to which, at *m*, a small portion of the granular liver still adheres; *n*, *n*, supra-renal capsules (renes succenturiatæ); *q*, *q*, the two laminæ of the mesentery, torn away at the point where these arise from the vertebral column; *o*, *o*, kidneys, composed of lobules, and, at this period, much smaller than the supra-renal bodies; *p*, *p*, ureters; *r*, intestinum rectum cut through; *s*, *s*, excretory ducts and remains of the Wolffian bodies; *t*, *t*, germ-preparing sexual organs, in all probability about to be transformed into ovaries; *u*, sinus urogenitalis, in this embryo, about to become the uterus; *v*, *v*, future Fallopian tubes; *w*, *w*, future round ligaments of the uterus; *x*, clitoris; *y*, longitudinal cleft in the same; *z*, fold behind the orifice of the anus.

talis, and is more fully divided into two cornua; and that the vagina is formed from the lower portion of the same uro-genital sinus; in the male, the urethra is also formed from the uro-genital sinus (vide figs. CI. CII. CIII. and CIV.). The vesiculæ seminales first appear in the fifth month as offsets from the vasa deferentia. The external organs of generation in both sexes have shown themselves so early as the end of the second month, in the

Fig. CI.

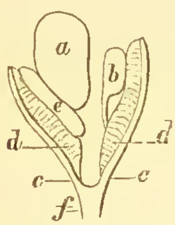
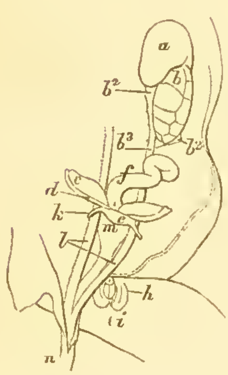


Fig. CI.—Magnified representation of the urinary and genital organs of a human embryo eight lines in length; *a*, supra-renal capsule of the right side, which completely covers the kidney lying behind it; *b*, left kidney, the left supra-renal capsule having been removed; *c, c*, excretory portion of the genital organs,—vas deferens, or Fallopian tube; *e*, germ-preparing portion of the sexual system,—testis, or ovary; *f*, sinus uro-genitalis. After Müller (*Bildungsgeschichte der Genitalien*, 1830). d Wolffian body

Fig. CII. Fig. CII.



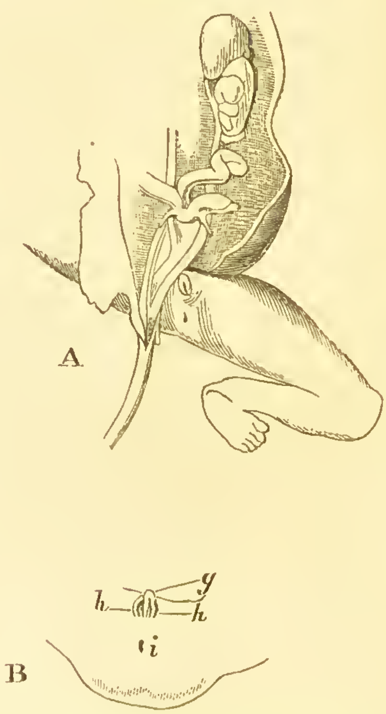


Fig. CII. *A* and *B*.—Internal and external organs of a fœtus of the fourth month, of the natural size. In *A*, the abdomen is laid open; the navel string, *n*, turned down; the left thigh and foot delineated; the club-foot appearance, that appertains to all embryos, is remarkable; *a*, left supra-renal capsule; *b*, kidney composed of many lobules; *b*², *b*², capsule of the kidney removed; *b*³, ureter; *c*, ovary; *d*, Fallopian tube; *e*, uterus; *k*, round ligament, running to the inguinal ring; *f*, rectum; *h*, labia majora, surrounding the clitoris; *i*, anal orifice; *l, l*, umbilical arteries; *m*, urinary bladder, produced into the urachus.

B, external genital organs in situ; *g*, clitoris, with the glans and rima, from the bottom of which a fold projects; *h, h*, labia pudendi majora; *i*, anus.

The embryo, now figured, bears a strong resemblance to that depicted by Müller (*loc. cit.* tab. iv. fig. 9.) which was 3½ inches long.

shape of small projecting wart-like eminences, which, in the third, acquire larger dimensions, as the clitoris or penis (fig. C. *x*), underneath which, and in the middle line of the perinæum there is a cleft or channel (*g*), which is modified variously according to the sex. In the female, the clitoris continues backward in its formation to the beginning of the fourth month; the lateral parietes of the inferior open channel are formed into the lesser labia, and, in the vicinity of these, the greater labia by and by appear as broader or more extensive tegumentary folds. In the male sex, the inferior open channel of the now erected and prominent penis is closed in the third month, and becomes the urethra, which now terminates on the extremity of the member; the scrotum is still cleft in the middle line, and consists of a couple of folds of common integument. The mouth and nostrils become fairly divided from one another by the formation of the velum palati and dental arches, the wide cleft that lay between them being thus effaced (fig. C. *a*). The dental sacs make their appearance in the lower and upper jaws. The stomach lies more transversely than heretofore; the omenta are more perfectly evolved; the small intestine forms several convolutions, has been entirely included within the abdomen since the tenth week, and now contains meconium; rugæ or folds appear upon the mucous membrane as rudiments of the future villi; the vermiform appendix appears by the side of the cœcum, which has already been some time formed. With the formation

Fig. CIII.

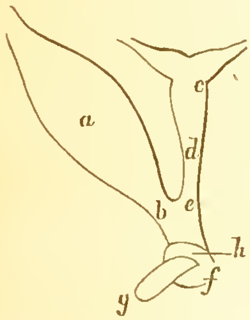


Fig. CIII.—Genital and uropoetic organs of a human fœtus $3\frac{1}{2}$ inches long, from the side; after Müller (*loc. cit.* tab. iv. C.); *a*, urinary bladder; *b*, urethra; *c*, uterus bicornis; *d*, vagina; *e*, anterior still common portion of the urethra and vagina; *f*, common aditus uro-genitalis; *g*, clitoris; *h*, labia pudendi majora.

Fig. CIV.

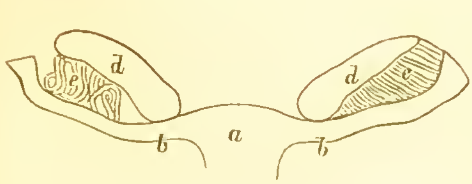


Fig. CIV.—Internal female genital organs of a human fœtus $4\frac{1}{2}$ inches long to the anus, seen from the dorsal aspect, and magnified; *a*, uterus; *b*, Fallopian tubes; *c*, abdominal end of one of these with its fimbriæ; *d*, ovaria; *e*, remains of the corpora Wolffiana.

of the perinæum in the third month, the anus, which had previously presented itself as a depression immediately behind the common opening of the sinus urogenitalis, appears as a distinct opening (fig. C. *z*), by which the sacrum is hollowed out anteriorly, and made to bend backwards. The gall-bladder, upon the liver, is elongated, and like a piece of intestine. In the heart, the sinuses are large, and divided from one another by external sulci; the division between the ventricles is indicated externally at the apex (fig. C. *f*, *g*,) and the septum ventriculorum is more complete; the Eustachian valve is large. The lungs receive small twigs from the pulmonary artery, which is now distinct from the ascending aorta; but this vessel still divides into two large arches, which by and by unite with two similar arches, proceeding from the aorta. Externally, the division between the head and trunk is more strongly indicated, so that the neck is produced. The abdominal region enlarges, comes forward, and the umbilical cord does not arise so low down, or so near the anus; the umbilical opening is extremely small. The embryo grows, in the course of the third month, to two inches and a half in length, and will weigh an ounce. (fig. CXIII.) The head is particularly large and globular. In the fourth month the embryo increases very rapidly; by the end of this month it measures four inches in length, and weighs about five ounces [142].

§ 75. With the fifth month, the first half of the period of fœtal life is concluded, and the embryo is now about twelve inches long. The epidermic formations now develope themselves particularly: the nails on the toes and fingers, which had already appeared, begin to be consistent or horny; the hair begins to sprout on the head, and the whole body is covered with a soft down—*lanugo*. The first motions of the fœtus are usually experienced about the beginning of the sixth month, and, by the mother, are

[142] Many of the above named organs appear, as I have just said, to be formed earlier than is generally imagined; in the sixth week, for example, I have observed the thymus as two very small, lax, white bodies, situated near and over the heart (fig. XCI.); at the beginning of the third month, this organ is much more distinct (fig. C. *e*); at this time, too, the thyroid gland is visible, and consists of two completely separated bodies (fig. C. *d*, *d*). I have discovered the rudiments of the parotid gland in the seventh week; it then consisted of a filiform excretory duct, upon which, several minute knots or buds, which by and by became sacs, were situated. The spleen appears as a narrow body, on the convex edge of the stomach; and where the stomach is terminating in the intestine, the pancreas shows itself as a congeries of distinct granules. For a more particular account of the development of the sexual organs, vide § 28.

felt as slight flutterings, and then as spasmodic jerks (motion probably occurs before this, but is not perceived by the parent); a child born prematurely at this time is capable of breathing. The head is still extremely large, and may, of itself, form a fourth part of the whole body; the face, from the wrinkles with which it is covered, has the appearance of that of an aged person; this character of the physiognomy disappears more and more with the increased secretion of fat, by which the whole body is rendered rounder and plumper. The resemblance between the external sexual organs, so remarkable on their first appearance, is entirely lost in the course of the preceding month; but the scrotum is still empty; the testicles approach the inguinal rings, but only descend completely into the scrotum in the course of the eighth or ninth month. At this time also, the glans penis first acquires a complete prepuce, although this part has appeared in the course of the fifth month as a fold of integument. In the seventh month, the embryo or fœtus measures sixteen inches in length, and weighs about two pounds; it is now capable of entering on an independent existence, and, if born prematurely, may be reared. The skin is red, and, besides the fine hair or down, is now covered with a layer of cheesy matter, the *vernix caseosa*,—a substance composed of detached epithelial nucleated scales and mucus (figs. CV. and CVI.). In the eighth month, the membrana pupillaris disappears; the epidermic scaling of the eyelids begins to loosen. In the ninth month, the bones of the cranium approximate more closely together, and the fontanelles become smaller; the hair, on the head, increases in quantity, and the woolly hair or down of the

Fig. CV.

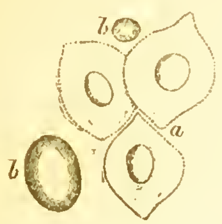


Fig. CV.—Epithelial laminæ, three of which are tesselated or connected like a piece of pavement, from the *vernix caseosa* of a new born infant; the cells are depressed, or flat, and transparent; the nuclei spread out; *b*, *b*, are oil-globules.

Fig. CVI.

Fig. CVI.—A single cell of this kind (epithelial lamella), treated with acetic acid, by which the nucleus has become more obvious, and itself exhibits a macula or nucleolus.

body generally falls off; the embryo is eighteen inehes in length, and weighs from five to six pounds. In the eourse of the tenth month, the size and weight of the fœtus vary greatly, measuring from eighteen to twenty inehes, and weighing from seven to ten pounds; nor are these by any means the limits, both length and weight being, in some eases, eonsiderably less, and the weight espeeially, in others somewhat more*.

Birth.

§ 76. The regular period of pregnaney in the human female ends with the tenth lunar month, or the fortieth week. The head of the embryo has now sunk downwards; and the period of delivery being eome, it advanees first into the os uteri, the membranes of the ovum having previously given way, and is then foreed by painful eontraetions of the uterus through the external organs of generation. In this proeess it makes a spiral turn in its eourse, and when the delivery is tardy, and espeeially when it is irregular from the presentation of the feet, imperfeet respiration may take plaee. In rare eases the ehild has even been said to have eried before the head was delivered; this is what has been termed vagitus uterinus. The possibility of sueh an oeeurrenee is not to be denied; its likelihood, however, is very slender, and sourees of fallaey or mistake are but too numerous [143].

The Uterus, and the Membranes produced by it.

§ 77. It is familiarly known that those eoverings of the fœtus in utero whieh lie externally to the ehorion do not belong to it originally, or are not derived from the ovum, but that they are a produet of the new aetions set up in the uterus. With regard to the mode in whieh the membranes derived from the uterus are produeed, very opposite views are entertained by different writers. These views have even been elaborated into formal theories, and anatomieal faets have been interpreted variously and in support of eaeh by its

[* *Quickening* is the term eommonly applied to the first motions of the fœtus as felt by the mother. It usually oecurs in the course of the 4th or 5th month. R. W.]

[143] The works on midwifery generally speak on the subject of vagitus uterinus; it is also discussed by Burdaeh, *Physiol.* iii. 95. The eases of vagitus reeorded seldom rest on calm and eareful observation. Accoucheurs in extensive practiee will almost always be found, when closely questioned, to speak of the oeeurrenee rather as something they had heard of, than as aught they had themselves observed. On the mechanism and means of parturition, vide the Third Book of this work.

author. We shall first take cognizance of the relations of these membranes to one another, as they appear on the most careful anatomical examination, and subsequently (§ 82), and altogether independently of the anatomical facts, inquire into the manner in which the ovum may have acquired its uterine envelopes [144]. Researches in regard to the state of the mucous membrane of the uterus, after conception [145], inform us that even before the arrival of the ovum within its cavity an exudation of albuminous fluid takes place from its surface, which, soon acquiring consistency and the appearance of concrete fibrine, is gradually formed into a membrane, thin and delicate at first, but which continually increases in thickness and finally presents a fac-simile or mould of the inner cavity of the uterus. This membrane even appears though the ovum never reaches the cavity of the uterus, but passes through the various stages of its evolution in the ovary, Fallopian tube, or abdomen [146]. In the course of the first week this lining

[144] There is scarcely a subject in anatomy and physiology which has occasioned so much controversy as this doctrine of the decidua. Putting out of the question such researches as are palpably erroneous and insufficient, and false hypothetical interpretations, many of the apparently contradictory opinions may be safely pronounced to be correct in regard to individual cases. The particulars in the text are given from my own reiterated observations and researches, and the views there set forth are illustrated by a series of figures entirely after nature, and by illustrative plans. For an account of the different views that have been held on the subject of the decidua, Burdach, Valentin, Velpeau, Breschet, Seiler, &c. may be consulted, as also my paper in Meckel's *Archiv*, for 1830, on the subject. Among the observers of the past age, Hunter distinguished himself pre-eminently both in profundity of description and in excellence of illustration. He also describes and figures the gelatinous mass which closes the cervix uteri. —Vide his *Anatomy of the Gravid Uterus*, tab. xxv. and xxvii. in the fifth month. I have merely stated facts here, as must be apparent; the explanation of these will be found by and by (§ 82).

[145] The observations of Baer and E. Weber are those that treat of the decidua at the earliest period of its existence, even before the entrance of the ovum into the uterus. Baer has described the decidua and its vascular connexions a week after conception.—Vide Siebold's *Journal*, vol. xiv. p. 403, with a figure, which is copied in fig. CVII. Weber's account of the decidua occurs in his edition of *Hildebrandt*, vol. iv. p. 466.

[146] The decidua is certainly found in the greater number of extra-uterine conceptions; when it is not found, it is perhaps overlooked, or mistaken for the spongy mucous membrane of the uterus. I have found it in this state in the uterus three or four weeks after parturition; [or the converse of this may be true; that which has been described as decidua vera in cases of extra-uterine gestation may have been but the mucous membrane of the uterus softer and more spongy than usual; or, otherwise, the uterus may have been lined with a plastic deposit preparatory to the reception of the ovum; but

fills all the foveoli or depressions of the mucous membrane of the uterus, and blood-vessels shoot from the uterus into its substance, so that it becomes organized; formal capillary retes may be demonstrated surrounding the villi of this new formation which penetrate the little depressions of the proper mucous surface (fig. CVII.). The thicker the membrane grows, the more perfectly does it become organized; its inner aspect, or that turned towards the cavity of the uterus, is smooth; its outer aspect, by which it adheres to the uterus, is villous and rough. Its thickness in the third or fourth month of pregnancy, when it is most perfectly developed, may be about a line, and at this period it may be completely detached from the uterus and exhibited apart (fig. CVIII.),

this may have been, nay, from the accounts often given of it and its appearance in preparations, certainly was different from the proper decidua, being a soft, lardy-looking, very thick, and unorganized layer,—not a thin reticulate vascular tissue, like the true decidua. That the decidua vera is no absolute product of the uterus, but of those living tissues with which the living ovum is in contact, seems demonstrated by this : that the ovum in extra-uterine gestations of all kinds is surrounded by a membrana decidua as it is when lodged in the cavity of the womb. When the ovum makes its way in due season and unimpeded into the uterus, it acquires its decidual covering there; if it be detained in the tube there it acquires its decidual covering likewise, and the uterus is without this membrane. The uterus having been found in a single instance of ovarian or tubal conception without the decidua, seems to the writer fatal to the theory of that membrane being the product of the uterus independently of the presence of the ovum. Nature admits of no exceptions to her laws. The decidua, indeed, as the bond between the mother and the embryonic chorion, is a formation indispensable to the development of the germ wherever this happens to take place, whether within the uterus, in the Fallopian tube, or in the cavity of the abdomen. There are two preparations of tubal gestation in the Museum of St. George's Hospital, which, whatever may be said as to the presence or absence of the true decidua in the uterus, certainly demonstrate the existence of this membrane around the ovum arrested in the Fallopian tube. See also a note by Dr. R. Lee, on the situation of the decidua in cases of extra-uterine gestation, in the *Lond. Med. Gazette,* for June, 1840. R. W.]

Fig. CVII.

Fig. CVII.—Internal superficies of the uterus with the decidua of Hunter in process of formation, from the body of the female from which the drawing of the Graafian follicle, given in fig. LIX was made. The villi, *a, a, a,* of the mucous membrane of the uterus have increased notably in length. The matter which is to become the membrana decidua is observed deposited between and upon the surface of the villi; *c, c,* are the uterine vessels extending into the decidua and there forming loops. (After Baer, *loc. cit.*)

it is then of a reddish gray, or whitish gray colour, and presents the consistency of concrete fibrine; examined under the microscope, it is found to be entirely composed of flattened cells, which have nuclei of from the $\frac{1}{200}$th to the $\frac{1}{300}$th of a line in diameter, and in addition to these, dark kernels more or less replete with fine molecules (as fluid of the cells)—(fig. CIX.); the cells are tessellated or arranged like a piece of pavement, one by the side of and laid over another, and are altogether different from the

Fig. CVIII.

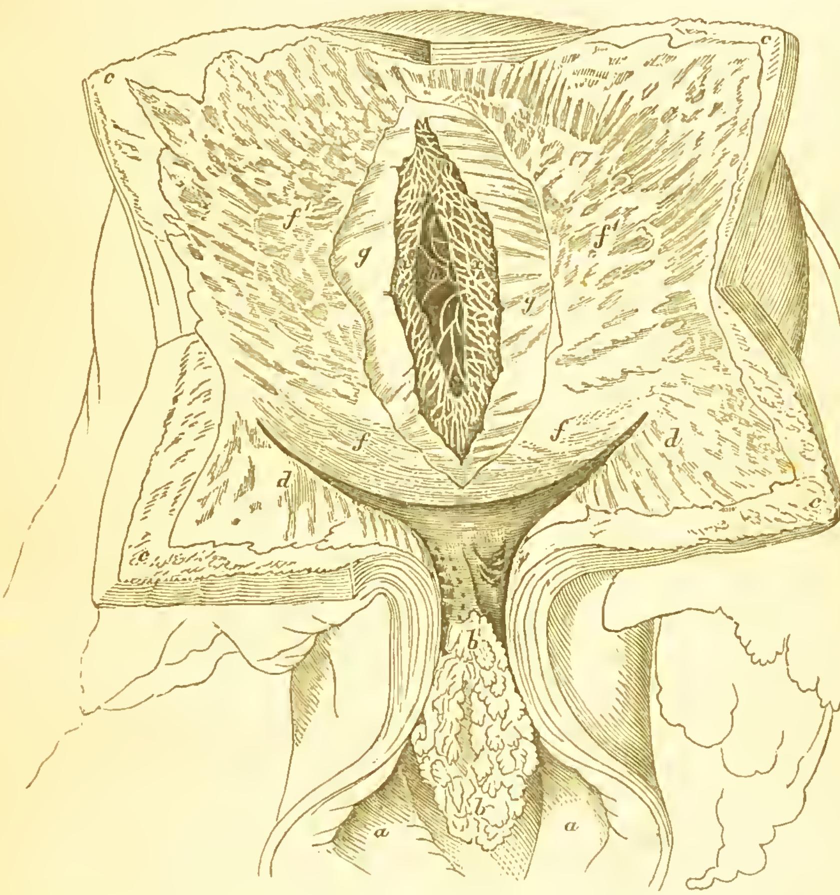


Fig. CVIII.—The gravid uterus at the end of the fourth month laid open and the involucra of the ovum delineated in situ. In the cervix uteri there is a great plug of gelatinous matter, the villi of which, from the preparation having been immersed in alcohol, are extremely distinct.—*a*, Os externum ; *b*, *b*, gelatinous plug filling the cervix uteri; *c*, *c*, *c*, the uterus reflected in four flaps; *d*, *d*, decidua vera lining the uterus ; *f*, *f*, the decidua reflexa passing into the vera by a circular fold, still smooth and unconnected inferiorly ; at f^1, f^1, however, it is rough, as at this part it was in contact with the decidua vera, and was only separated from this by force ; *g*, villi of the chorion ; *h*, amnion ; *x*, *x*, *x*, *x*, tunica media, lying betwixt the amnion, *h*, and the chorion, *f*, and forming a veritable membrane.

cylinder-epithelium of the proper uterine mucous membrane, which at this time appears to have been detached, and given way to a new production. The DECIDUA VERA, as this new membrane is called, either forms a completely shut sac, in which case it covers the orifices of the tubes, and even sends processes into them and the os uteri; or it forms a pouch partially shut, being wanting in these situations; the decidua is most commonly absent over the os uteri, where considerable flap-like appendages or growths occasionally present themselves hanging from it (plan, fig. CX. and fig. CXIII.); it is also frequently wanting over the mouths of the Fallopian tubes (fig. XCVI.) [147]. It is only now and then that the decidua vera is formed extending some little way into the

[147] I am firmly persuaded from my own experience that the hotly contested point of the presence or absence of the three openings amounts to nothing. Every one, from the time of Hunter, who has described one, two, or three openings, or who has denied the existence of any, may in his turn be right, or he may be wrong: if the exudation have been copious, the whole of the three natural openings of the uterus may be covered, and a completely closed membrane thus produced; but the exudation being more scanty, one or two, or all three of the openings may escape a covering, and then there is a decidua with a corresponding number of outlets; the opening into the cervix uteri as the largest of the three openings is most apt to escape a covering, and so it is here that the decidua is most frequently found defective.

FIG. CIX.

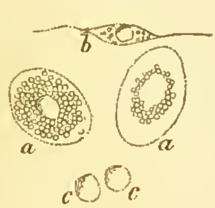


Fig. CIX.—*a*, *a*, Cells of the decidua vera of a recent ovum of six weeks; the nucleus in the middle is surrounded by molecules; *b*, section of a cell of this kind; *c*, *c*, nuclei removed from the cells, of the $\frac{1}{200}$th and $\frac{1}{300}$th of a line in diameter.

FIG. CX.

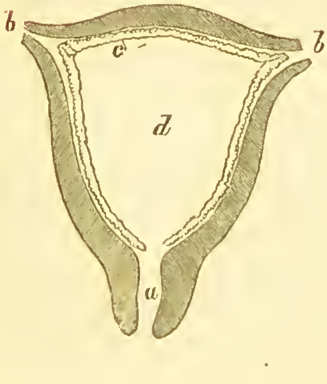


Fig. CX.—Sectional plan of the uterus about eight days after impregnation; *a*, neck of the uterus; *b*, *b*, entrances to the Fallopian tubes; *c*, decidua vera, covering the walls of the uterus at every point; *d*, cavity of the uterus.

cervix uteri, within which a plug of gelatinous-looking matter is generally observed, that acquires great consistency by digestion in alcohol, looks villous on the surface when detached, and is produced from the foveoli of the mucous membrane of the part it occupies. This gelatinous production appears as a delicate exudation in the second month, acquires size and consistency in the third (fig. CXIII.), and reaches its highest development in the fourth (fig. CVIII.); it may be regarded as a peculiar formation, and attains its most perfect state at the same time as the decidua vera. If the uterus be examined during the first half of the period of pregnancy,—and researches are best made in the course of the second and third month,—the ovum will be found not to be surrounded immediately by and in contact with the internal surface of the decidua vera, but to be included within a pouch of this membrane, which consequently looks as if it had grown inwards at a particular place and hung like a sac containing the ovum into its own internal cavity (plan figs. CXI. and CXII. and figs. CVIII. and CXIII.). The membrane which surrounds or covers the ovum immediately is called the *decidua reflexa;* in structure it is precisely similar to the decidua vera, but on the whole thinner, smooth on its outer surface, which is turned towards the decidua vera, and, like the inner aspect of the latter, furnished with slight depressions; towards the ovum, again, it is rough or shaggy, and its processes, or villi, hang towards and coalesce with those of the outer aspect of the chorion, from

FIG. CXI.

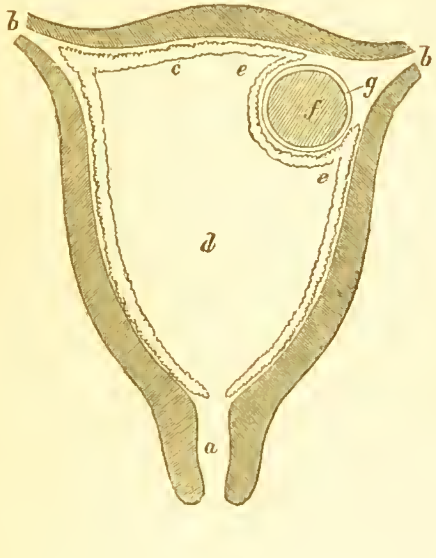


Fig. CXI.—Plan of the uterus at the moment when the ovum *f*, surrounded with its chorion *g*, is entering its cavity, and pushing the decidua vera before it to form the decidua reflexa. *a*, Neck of the uterus; *b*, *b*, entrances to the Fallopian tubes; *c*, decidua vera, covering the walls of the uterus at every point; *d*, cavity of the uterus.

which, though they may be easily enough separated at first, this is done with more difficulty by-and-by, and in the third month it is not to be accomplished at all. At one part the ovum is covered neither by the decidua vera nor by the decidua reflexa; this is where the placenta is formed, and usually indicates the point of reflexion of the decidua reflexa; here there is a thick stratum of a substance precisely similar to the decidua reflexa, which attaches the ovum to the wall of the uterus, and which blends intimately on the outer side of the reflex fold with the decidua vera; this thick stratum is named the *decidua serotina,* from its appearing to have been formed at a later period. In those cases in which extra-uterine conception has taken place, the decidua vera alone is met with, the reflexa and serotina are wanting. The cavity then contains an albuminous fluid, which, in ordinary cases, also occupies the space between the decidua vera and decidua reflexa, so long as the two continue unconnected (*hydroperione* of Breschet).

These twofold membranes, the decidua vera and decidua reflexa,

Fig. CXII.

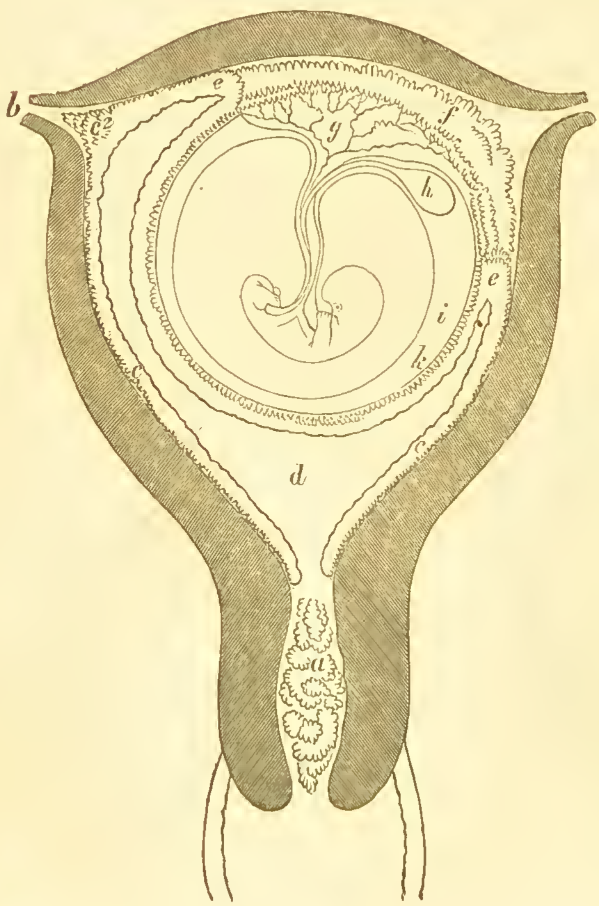


Fig. CXII.—Sectional plan of the uterus with the ovum further advanced; the cervix uteri is now plugged up with a gelatinous mass, *a*; the decidua vera, *c*, sends a process, c^2, into the right Fallopian tube; the cavity of the uterus is almost completely occupied by the ovum; *e, e,* points of reflexion of the decidua reflexa; *f,* decidua serotina; *g,* allantois; *h,* umbilical vesicle, with its pedicle in the umbilical cord; *i,* amnion; *k,* chorion; between the two the space for the albumen.

may be not unfrequently demonstrated in aborted ova of the first three months; occasionally the ovum is surrounded by both the sacs shut and quite entire; more commonly, however, the decidua vera can alone be traced, and that is in flaps of various sizes (fig.

Fig. CXIII.

Fig. CXIII.—Uterus, with an included ovum, in the twelfth or thirteenth week of pregnancy. The cervix uteri is closed with a mucous or gelatinous plug; the membranes are opened and the embryo is taken *e situ*, but is still attached by the naval string. *a*, Os externum; *b*, *b*, gelatinous plug of the cervix uteri; *c*, *c*, *c*, *c*, the uterus reflected in four flaps; *d*, *d*, *d*, *d*, decidua vera spread over the inner aspect of the uterus; *e*, *e*, two great smooth flaps of the decidua vera, drawn somewhat apart; they closed the internal orifice of the uterus; *f*, *f*, decidua reflexa, passing by a circular fold or reflexion into the decidua vera; *g*, *g*, *g*, villi of the chorion; *h*, amnion; *i*, umbilical vesicle; *k*, umbilical cord; *l*, embryo; *m*, opening of the decidua into the orifice of the left Fallopian tube; *x*, space between the amnion and chorion for the tunica media. [The parts are represented of two-thirds the natural size.]

LXXXVIII. *a,p*), hanging from the point of reflexion. The deeidua reflexa is usually mueh altered, and thieker instead of thinner than natural, in eonsequenee of the infiltration of blood into its substanee,—an aeeident whieh is often intimately eonneeted with the oeeurrenee of abortion [148]. In some few instanees the reflexa seems aetually to be wanting, a faet for whieh researehes on the pregnant uterus itself, as well as on otherwise normal aborted ova, appear to voueh [149]. In the later periods of pregnaney, the two deeiduous membranes are parted with inereasing diffieulty, and at last they are not to be separated at all; they grow together probably in eonsequenee of the eontaet and the pressure oeeasioned by the enlarged and still enlarging ovum; but even in ova that have attained maturity, and in the after-birth, they ean still be demonstrated as a simple, pretty thiek, and eohering membrane [150]. Still later, for several weeks after parturition, the mueous membrane of the uterus is extremely loose and spongy, and small shreds or portions of it are even thrown off along with the loehial diseharge.

148 Sueh cases, in whieh in aborted ova the deeidua vera presents itself in a varying state of eompleteness over the reflexa, are very numerous, and I should say that a flap at the point of reflexion was the rule. As observations upon this point are far more readily made on aborted ova than on sueh as are still contained in the uterus, I shall here mention a few partieular plaees where they may be eonsulted, merely stating that fig. XC. may be taken as a kind of type of them all:—Hunter, on the *Gravid Uterus*, tab. xxxiii. figs. 1, 2, 3, 4, eopied by Loder, *Tab. Anatom.* tab. xe. figs. 1, 2, 3, 4; Velpeau, tab. viii. figs. 3 and 7, tab. xi. fig. 2; Breschet, tab. ii. fig. 3, tab. iv. fig. 5; Boek, *Diss. de Membrana Decidua Hunteri,* Bonn, 1831; Kilian, *Geburtsh. Atlas,* tab. xxiv. fig. 2, where the figures are as true to nature as they are beautiful; Mayer, *Icones Selectæ,* Bonn, 1831, tab. v. fig. 7.

149 I have never found the deeidua reflexa wanting in the uterus, although this is said oecasionally to be the case by several observers. But then it was wanting in the normally-formed ovum of the third week, represented in fig. LXXXIII.; here the decidua vera surrounded the ovum elosely with its smooth surface: it was shaggy externally, completely elosed, and formed a mould of the inner eavity of the uterus; it was readily detached as a eomplete sae. On the possibility of the oecurrenee of sueh a formation of the decidua, vide later (§ 82).

150 Hunter was aware of the persistenee of the deeidua to the period of birth, and speaks of the mode in which it presents itself in the secundines; but Bischoff, in his "*Contributions to the Doctrine of the Membranes of the Human Fœtus*" (*Beiträge zur Lehre von den Eihüllen,* &e. Bonn, 1834), gives a more particular account of the matter. He shows the presenee of two membranes in the after-birth, which are unquestionably the united decidua vera and deeidua reflexa. What Bischoff speaks of as probable, I have had oeeasion to eonfirm in regard to both the vera and reflexa being originally furnished with vessels; they are only fewer in the latter than in the former. The cells are still very dis-

Among the mammalia a decidua vera can always be demonstrated, but in none of them does the decidua reflexa appear to be present[151].

Of the Fœtal Envelopes produced originally from the Ovum, or subsequently from the Embryo.

§ 78. At the earliest periods at which human ova have yet been examined in the uterus,—and this has been when they were but of the size of a pea,—the CHORION has been found surrounding the embryo loosely as a simple membrane, shut on all sides, smooth internally, rough from the presence of short cylindrical villi externally,—a kind of epithelial basis of the future membrane, with its various peculiarities[152]. In ova that are somewhat farther advanced,

tinct here, and look like transparent bladders, often full of molecules, but with very clear nuclei.—Vide fig. CXIV.

[151] In the bitch, precisely as in the human subject, there is a lining membrane analogous to the decidua in all respects, formed in the uterus before the arrival of the ova within its cavity; it is vascular, thick, and covered on its surface with large cells like those of a honeycomb.—Vide Baer, in *Entwickelungsg.* ii. 242, and Bojanus's *Figures in Nova Acta Acad. Nat. Cur.* vol. x. pl. viii. fig. 1, b. ii. 3 c. The reason of the absence of the decidua reflexa in animals as well as of its presence in man, lies in the dissimilar form of the uterus and relations of the oviducts to it; in animals, the oviduct or Fallopian tube expands and opens gradually, or rather is continued freely, into the uterus; in the human subject, on the contrary, it enters the thick walls of the uterus as a very slender canal, and opens by a narrow orifice and at a right angle upon its inner surface.

[152] It would be needless here to mention the numerous writers on the chorion and the rest of the fœtal membranes; I shall merely quote particularly the monograph of Bischoff upon the subject, entitled, "Contributions to the Doctrine of the Membranes of the human Fœtus" (*Beiträge zur Lehre, &c.*, Bonn, 1834.), written with much critical acumen, and based on numerous individual inquiries. The account in the text is principally after my own observations and inquiries. Some microscopical researches upon the membranes by Breschet and Gluge will be found in the *Ann. des Sciences, Nat.* t. viii. p. 224, with which my

Fig. CXIV.

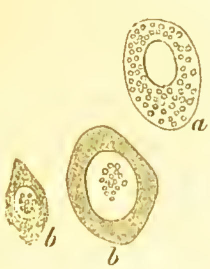


Fig. CXIV.—Cells of the placentary decidua of an ovum arrived at the full time. The nuclei are extremely plain; in the cells *b*, *b*, treated with acetic acid, the granular corpuscules of the nuclei have become apparent.

the villi are less crowded; they protrude in the form of considerably broader vesicles; the spaces betwixt them are wider and smooth, and they end in more delicate, rounded extremities. At the beginning of the second, perhaps in the course of the first month, the villi are observed to divide into branches, which arise from short thin stems, and terminate either thin or filiform, or in vesicular enlargements (fig. CXV.). The smooth interspaces increase continually in extent; the membrane even shows a general tendency to become naked, all but in one particular part, which was without villi at an earlier period; this now becomes thickly covered with villi, and here they go on increasing in a much greater proportion than in other situations, so that the chorion of ova about the middle of the period of pregnancy is generally smooth externally, whilst in the part indicated, the dendritic villi are large, closely crowded together, and here coalesce in an especial manner with the decidua, pushing their ramifications into the thick stratum of the decidua serotina: in this manner and in the course of the third month is the PLACENTA formed. The chorion is entirely without vascularity, and is a membrane made up of cells, which in many parts compose a structure that bears the closest resemblance to that of vegetables; each cell contains a large distinct nucleus (fig. CXVI.); the villi participate in the same structure, but their cells are farther filled with a granular matter. (fig. CXVI). From the inner wall of the chorion, especially over the placenta, a layer may be detached

own observations agree in the main. Perhaps the best drawings of the chorion, and its appendages, extant, occur in Seiler's work, " The Uterus and Ovum of Man (*Die Gebärmutter und das Ei des Menschen*, Dresden, 1832).

FIG. CXV.

Fig. CXV. One of the villi of the chorion arising by a single root, but dividing into numerous branches, natural size. It is one of the villi of the ovum depicted in Fig. XCVI.

FIG. CXVI.

Fig. CXVI. Cells from the villi of the chorion of a recent ovum of the sixth week: *a, a,* cells plentifully filled with molecules; *b,* a nucleus isolated.

more or less obviously, which is very vascular, penetrates among the villi, and carries in large convoluted bundles of vessels, which run to the ends of the villi. This vascular lamina, which cannot be demonstrated at every point of the circumference, is named the Endochorion, in contradistinction to the outer lamina, which is called the Exochorion[154]. In ova that have not been injured, and in such as are examined in situ within the uterus during the third and fourth months, a separate, extremely delicate arachnoid membrane will be observed enveloping the amnion loosely, but completely, and situated between that membrane and the chorion (fig. CVIII.). This membrane may also be readily demonstrated in its separate condition through the whole of the second half of the period of pregnancy, and even in the secundines of ova that have attained the full period. It is usually distinguished by the name of the *tunica media*, or middle tunic[155]. In the first months of pregnancy, instead of the membrane now described, an albuminous mass of very various consistency is found, often intermingled with numerous flocculi and threads, occasionally pulpy or gelatinous, and still oftener arachnoidal in its characters. Put into spirit, this mass assumes the appearance of the cellular tissue that is found between the muscles, and seems in fact to stand in the same relation to the amnion and chorion as the intermuscular cellular membrane does to the fasciculi between which it lies: this mass occupies the space, in young ova still considerable, which intervenes between the amnion and chorion (fig. XC. *f*). This matter or tissue has been designated by different names, and been very commonly compared to the albumen of the egg of the bird and certain other animals[156]. Next comes the amnion, which envelopes the fœtus immediately, lying very close to it in the earlier periods, and being continued immediately into the outer covering or common integument of the embryo by the open abdominal parietes (fig. LXXXVIII. and figs. CXXIII. and CXXIV.). In older ova the amnion is in contact with the chorion, or rather with the inter-

[154] The distinction between the exochorion and endochorion was drawn by Burdach; the latter he regards as formed by the union of the allantois. Vide § 80.

[155] Bischoff has given a careful account of the tunica media as a distinct membrane in ova at the full time (l. c.); I have again and again observed it in ova of every age; I agree in essentials with Bischoff's view, that it is formed by the compression and consolidation of the mass named the albumen ovi.

[156] This formation, described by Müller, Valentin, and others, as albumen, is spoken of by some (Velpeau for instance) as the allantois, and is called by different names—arachnoidal membrane, magma reticulare, &c.

posed tunica media; but from this it is easily removed: it covers the umbilical cord externally, and at the umbilicus is continuous with the common integument of the fœtus: it is filled with a watery, very slightly albuminous fluid, the liquor amnii, in which flocculi (epithelial scales detached from the surface of the embryo) are commonly seen suspended. The liquor amnii shows strong alkaline reaction, and contains albumen and salts of the phosphoric, sulphuric, and carbonic acids [157].

Of the umbilical Vesicle.

§ 79. The difference and dispute to which the umbilical vesicle gave rise among the writers of the by-gone age, may be held as reconciled and ended by the concurring views of observers of the present day [158]. It is now satisfactorily demonstrated, that the umbilical vesicle is constantly present as a normal formation in the earlier months of pregnancy, and that it is connected with the intestinal canal. Repeated observation has shown that the umbilical vesicle is relatively very large in the youngest embryos, that it rests immediately upon the intestine, and communicates with its cavity, having, at this time, a rounded or oval form (figs. LXXXIV. and LXXXV.). At a very early period, however, it becomes pedunculated; its neck is produced into a canal, which is hollow at first, so that its contents can be pressed backwards and forwards into the bowel [159]. This canal or pedicle is of very different

[157] Writers seem to agree much more generally in their views of the amnion than of any of the other membranes; few, however, have seen it still open, and enveloping the embryo closely. Vide § 72. According to chemical analysis the liquor amnii contains from ninety-six to ninety-eight parts of water, from one to three parts of albumen, and smaller quantities of the lactates and phosphates of soda, and a little potash. The statement of Frommherz and Gugert that the liquor amnii contained urea, Berzelius regards as requiring confirmation; physiologically such a circumstance is very unlikely.

[158] Mayer seems the only modern anatomist who still seems to call in question the original communication of the umbilical vesicle with the intestinal canal, although he admits its analogy with the vitellary sac of birds. (*Nov. Act. Acad. Nat. Curios.* vol. xvii. p. 555.)

[159] Velpeau, in the plainest manner, saw that the pedicle was hollow, in different ova he could press the yellowish fluid contained in the vesicle into the intestine (l. c. p. 33). Baer says (l. c. p. 271), "that this yolk-duct is a pervious canal, I have satisfied myself, I think in almost every ovum of six weeks that I have yet examined; in some, I found the communication very free, and once I distinctly saw vitellary matter in the lower intestine." These views, themselves deduced from observation, are supported by the researches of Hunter, Pockels, Bojanus, Oken, Kieser, Müller, Burdach, Bischoff, and myself. The umbilical

lengths in different embryos; in those that are more mature, the umbilical vesicle is often found nearer the abdomen than in others that are much less advanced. It does not long remain pervious; at the end of the first month it is already filiform (fig. LXXXVI.). With the increase of the amnion, the umbilical vesicle is found as a pyriform body betwixt this membrane and the chorion (fig. XCVI.); it collapses more and more; the pedicle is obliterated in the second month, and becomes an extremely fine thread, which, however, may be traced to the end of the noose of intestine contained within the umbilical cord (figs. XCI. *g*, XCIII. *b*). Such continues to be the condition of the umbilical vesicle to the end of pregnancy, when it may still be demonstrated in the membranes; the shrunk vesicle itself may be discovered between the amnion and chorion, and a filiform appendage traced from it into the umbilical cord [160]. It contains a yellowish white, sometimes yolk-yellow coloured fluid, in which numerous globules and oil-globules are suspended. It appears to consist of two laminæ, an external vascular, and an internal mucous layer, which, as in the yolk-bag of birds, generally presents a villous and plicated inner superficies. It rarely happens, that anything like a vascular rete can be perceived externally; when it is apparent, its meshes are rhomboidal in figure, and cover the entire surface (fig. CXVII.); it is much more common to observe blood-vessels on the pedicle; these consist of an artery—the omphalo-mesenteric artery, which arises from the aorta, and passes over the intestinal loop of the

vesicle, however, it is well to be aware, is very commonly found obliterated in aborted ova of six weeks: vid. figs. XCI. XCII. and XCIII. One of the best figures of this relation of the umbilical vesicle to the intestine extant is that of Kieser, which is contained in his work, *On the Origin of the intestinal Canal, from the umbilical Vesicle, (Ueber den Ursprung des Darmkanals, &c.* Gotting. 1810.)

[160] This late existence of the umbilical vesicle has recently been particularly demonstrated by Mayer (l. c.) and illustrated by very beautiful drawings.

Fig. CXVII.

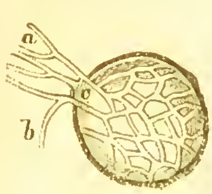


Fig. CXVII.—A magnified umbilical vesicle, somewhat freed from super-imposed structures, to show the vascular net-work that covers its surface; *a* and *b*, portions of the amnion; vessels are seen proceeding from these points towards the umbilical vesicle; *c*, duct of the umbilical vesicle, returning to join the intestine. (After Baer, loc. cit.)

umbilicus (fig. XCIII. *c*), and a vein—the omphalo-mesenteric vein, which terminates in the vena cava *d* [161].

Review of the doctrine of the Allantois.

§ 80. No part, in the history of the development of the human embryo is so obscure, or none so difficult to study, as that which has the ALLANTOIS for its object; no where is it more necessary to revert to the development of birds and mammalia to seek light than here. In the chick we have seen the allantois formed from the lower intestine, and making its appearance on the third day as a pyriform vesicle, which grew rapidly, consisting originally of the mucous layer above, but receiving a covering from the vascular layer at a very early period, and then presenting a thick net-work of blood-vessels, consisting of two umbilical arteries, and an umbilical vein. Thus constituted, the allantois shoots into the space between the amnion and the serous investment, grows quickly around the embryo as a flattened bag or bladder, lying all the while close to the membrane of the shell, and coalescing by its two contingent surfaces, it finally forms a membrane that envelopes the ovum or embryo completely, and is now known by the name of chorion. The allantois of birds continues in open communication with the cloaca by means of a pedicle, and the fluids secreted, in the first instance by the Wolffian bodies, and then by the kidneys, are transmitted to its cavity, which, therefore, actually contains urine, and often, by the end of the period of incubation, whitish concretions or deposits, which, when examined chemically, are found to consist in great part of uric acid [162]. In all the orders of mammalia, so far as observation has yet extended, an allantois has been found to be formed in a very similar manner; it arises as a small vesicle from the cloaca, and is speedily covered by a vascular lamina, carrying along with it, precisely as in birds, two umbilical

[161] Kieser has given figures of these vessels, and they are finely shown in the figure of an ovum of eight weeks, by Seiler (*op. cit.* tab. x.). Baer has likewise represented the vascular rete of the umbilical vesicle in an ovum of the fifth week; he could discover no sinus terminalis; on the inner surface of the umbilical vesicle, however, he discovered extremely minute villi, similar to those of the yolk-bag of birds (*op. cit.* ii. tab. vii. figs. 18, 19).—Siebold's *Journal*, p. 406, fig. v., copied fig. cxvii. Vide also corresponding relations of the vessels in the dog, fig. LXXIX. *A, B, C*, p. 159, after Bojanus.

[162] On the development of the allantois of birds, vide the first chapter of this section. Jacobson found the whitish concretions composed almost entirely of uric acid.

arteries from the aorta, and two veins, which generally unite into a single trunk, and proceed as the umbilical vein to the vena cava. With the formation of the navel-string, the portion which lies within the abdomen becomes partially divided at the umbilicus from that which lies without it; the intra-abdominal portion enlarges, and is transformed into the urinary bladder; the constricted portion at the umbilicus lengthens out into a hollow canal—the urachus, which leads to the extra-abdominal portion or allantois, which now presents itself as a bladder of various size and figure, lying between the amnion and chorion, and filled with fluid, which, as in birds, is at last urinous in its characters. In many families of mammalia, as, for example, in the solidungula, where the allantois grows to a great length, tears through the chorion at either end, and distends the whole uterus, the vascular is detached from the mucous layer; the former shoots with its vessels into the chorion; the latter remains as a completely unvascular sac, in communication with the urachus. In the carnivora, the allantois arises in the same manner, advances, coalesces by its outer most vascular surface with the chorion, sends processes into the villi of this membrane, and thus forms the placenta; here there appears to be no separation of a mucous layer (fig. LXXIX. *A*, from the dog) [163]. White concretions are also frequently found in the fluid of the allantois of many mammalia. In the human being it is only in the very earliest periods that traces of an allantois can be discovered; but the observations that bear upon this point are helped out, and rendered more complete by the occurrence of certain abnormal states, occasionally met with in ova of an early period, in consequence of imperfect development, or an arrest of evolution experienced in some prior stage. In embryos from a fortnight to three weeks old, in which the abdomen is still widely open, a pyriform bladder is seen springing from the lower extremity of the intestine, which contains vessels, and is directed towards the chorion; embryos often perish before this has occurred, when the allantois lies in the form of a bladder, near or under the umbilical vesicle [164]. In ova that are somewhat

[163] Baer describes the various forms of the allantois in particular families of mammalia in the second part of his *History of Development*, p. 193.

[164] I am disposed to regard the representation of Pockels (*Isis*, 1825, tab. xii.) of Coste (*Embryologie*, tab. iii. figs. 4 and 5,) and of Baer, (in *Siebold's Journal*, figs. vii. and viii., and *History of Development*, tab. vi. figs. 16 and 17,) as instances in which the human allantois is more or less obvious, in some of which indeed it has retained its genuine original form.

farther advanced, this bladder is observed to have become broader, and is in contact to a greater or less extent with the chorion (fig. LXXXV. *h*—*n*); here it is easy to trace the broad open duct from the cloaca to the chorion (n^1); about this time the mucous layer seems to separate from the vascular layer; the latter, in all probability, betakes itself, in its rudimentary state, to join the chorion; with the closure of the abdomen, and the greater extent to which the mucous layer is produced, the duct becomes continually smaller and narrower; though it may often still be inflated with air in the course of the fifth week; the funnel-shaped extremity with which it approaches the chorion is perceived, and here, white concretions, like little pieces of friable chalk, are frequently met with [165]. Towards the embryo, again, the duct becomes wider, and terminates in the urinary bladder, which has just been separated from the intestine. Small pear-shaped vesicular dilatations often remain within the navel-string, which are more or less distinct from the tract of the duct, and are frequently occasioned by the presence of concretions [166]. The remains of the allantoic duct, or urachus, which had been obliterated at an early period, may be demonstrated in the umbilical cord.

Of the Placenta and Umbilical Cord.

§ 81. We have already seen (§ 72 and 73) that the chorion is at first covered with villi nearly to the same extent over every part

[165] Many writers, and, among the number, Jo. Müller (in Meckel's *Archiv*, 1830), speak of such concretions. Unfortunately, one which I had, myself, found within the allantoic duct, as it passed into the chorion, was lost by the chemist, to whom I had sent it for analysis. I have filled the allantoic canal distinctly with air, as it lay near the canal of the umbilical vesicle. Two of the figures, 9 and 10, of Baer's tab. vi. appear to refer to this point. The particulars, stated in the text, are all based on my own researches.

[166] Von Baer has descanted at some length on these vesicles in the course of the umbilical cord; and has represented in the fourteenth fig. of his pl. vi. He also refers to the figure of Seiler, tab. x. as exhibiting the same subject. Pockels has described and figured one of these bladders, under the name of erythrois; Seiler has done the same thing under that of allantois. In regard to the formation of the allantois in man, Von Baer holds one of two modes possible; either the lamina vasculosa is raised from its original situation, and applied in the form of a membrane to the outer membrane of the ovum (the chorion), and more or less to the amnion also, or there is no division according to its component layers; but the vessels, as soon as the allantois has reached the outer envelope of the ovum, shoot into and find a nidus in this, when the allantois, now become superfluous, increases no farther. The latter, Baer is induced, from his researches, to regard as the more probable mode of formation.

of its surfaee, and that these villi beeome coneentrated, as it were, in the eourse of the third month, upon a partieular part, where they grow with great luxurianee, the rest of the ehorion beeoming in the same proportion smooth. The eoneentration of the villi oeeurs in eonsequenee of the produetion of vessels in the interior from the allantoie layer of the ehorion—the endoehorion ; it is, in faet, only at the plaee where the umbilieal vessels are partieularly developed, that the villi inerease continually in size, and this usually oeeurs in the situation where the deeidua vera is refleeted to beeome the deeidua reflexa. Vessels are also originally developed over the superfieies of the ehorion in general, and penetrate with its villi into the deeidua; but they soon shrink and disappear. As additional matter is poured out by the walls of the uterus at the part where the vessels and villi are especially enlarged, a thiekening takes plaee, whieh has been spoken of under the title of the deeidua serotina ; and this gives origin to the PLACENTA, a more or less regularly eireular, diseoidal, and well defined mass towards the end of pregnaney. The maternal blood-vessels enter freely into this formation ; the arteries appear to pass quiekly into capaeious veins, having very thin parietes, by whieh a tissue or network of eapillaries of extremely wide calibre is produced, amidst whieh the vessels of the embryo ramify. The two umbilical arteries run tortuous along the elongated navel-string, divide into large branehes upon that surface of the plaeenta which is turned towards the membranes of the ovum, and then plunge along with the villi into the substanee of the mass ; they run still tortuous in the hollow di-

FIG. CXVIII.

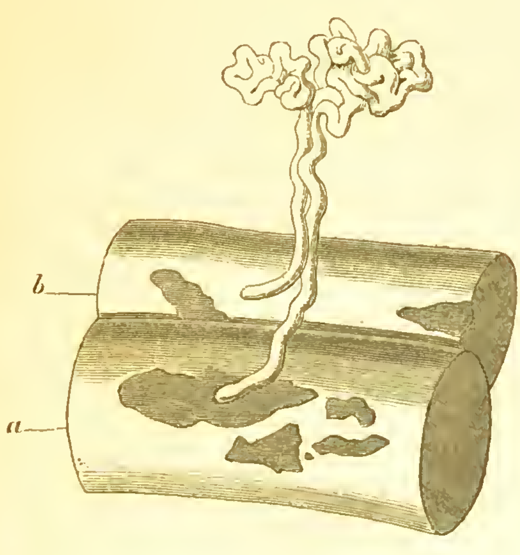


Fig. CXVIII.—A very small and extremely simple villus from the fœtal portion of the human placenta, the vessels of which have been successfully injected. An instance of the kind in which the origin of the capillary vessel distributed to the villus is seen, is extremely rare : *a*, the artery ; *b*, the vein.

visions of the villi to their blind extremities, and then turn round and terminate in the veins. Occasionally a delicate arterial twig is seen proceeding from a larger stem (fig. CXVIII.), and terminating almost immediately in a vein, which in its turn runs to join a larger venous trunk. Such simple terminal nooses of arteries in veins are rare; the arterial trunks more commonly divide and subdivide again and again, by which dendritic formations are produced of the same extent as the villi. The different venous roots collect like the arteries on the embryonic aspect of the placenta into larger and larger branches, and finally pour their tide in common into the umbilical vein, which, after tracking the umbilical cord, enters the body of the fœtus, and here terminates in the hepatic vein, close to the trunk of the vena cava inferior. These embryonic vessels have nowhere any direct communication with the vessels of the mother; besides their own parietes the two sets of vessels have always a layer of the chorion interposed between them (fig. CXIX.). The maternal vessels surround the villi of the chorion with their included embryonic vessels, in a continuous but perfectly distinct rete, which, however, appears to be composed of extremely delicate canals, with a wide internal diameter—at least as regards the veins [167].

[167] Weber is the modern anatomist who has investigated with the greatest care the structure of the placenta, and the mode of division and distribution of its blood-vessels—matters of great interest as regards the explanation of the way in which the fœtus is nourished. Vide his edition of Hildebrandt's *Anatomy*, iv. p. 495 et seq. Here, as well as in every manual of anatomy, a particular

Fig. CXIX.

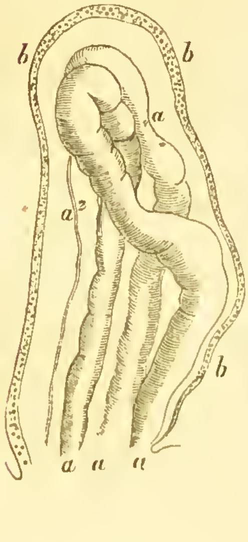


Fig. CXIX.—Termination of a villus of the chorion, from a ripe and perfectly recent placenta, the vessels still filled with blood, magnified two hundred and ninety times. The vessels, *a*, *a*, *a*, are full of blood; the one a^2 is empty. They measure from the $\frac{1}{100}$th to the $\frac{1}{120}$th of a line in diameter.—*b*, *b*, Pellucid margin of the villus.

Summary view of the morphological development of the Human Embryo.

§ 82. The observations now communicated upon the development of the ovum and embryo of the human subject, though they cannot

account of the structure of the navel-string will be found, a subject which does not properly pertain to an elementary work on physiology. Weber's views have given occasion to a good deal of controversy, and I here present an extract from the manuscript communication of that able anatomist, supplied to me for the purpose of publication. He says: "Eschricht of Copenhagen, in an interesting academical tract entitled, *De Organis quæ respiratione fœtus Mammalium inserviunt, Prolusio Academica,* Hafniæ, 1837, 4to, shows that he agrees with me in many points in regard to the structure of the placenta of man and animals, whilst on others he proclaims his dissent. The particulars in which he agrees with me are the following. 1st. That the arteries and veins of the uterus, the channels of the mother's blood, penetrate in great numbers into the placenta, and are distributed throughout its substance in such wise, that every one of its minutest lobules has a canal carrying the blood of the mother, and so comes into contact with the vessels in which the blood of the embryo is flowing. Here we both differ from Seiler, who believed himself authorized to conclude that no vessels from the mother penetrated the placenta, but that the maternal vessels only came into contact with the surface of the placenta, where it was bounded by the uterus. 2d. The umbilical arteries of the embryo divide, in the manner of a tree, into very numerous and minute branches, which finally turn round, forming loops and anastomoses, and again collect into larger and fewer branches, which at length unite into a single trunk, and form the umbilical vein. No where do the maternal and fœtal vessels anastomose; no where is there any transmission of blood from the one class of vessels to the other; no where do we encounter open-mouthed terminations of vessels. 3d. The whole placenta, and therefore every individual lobule entering into its structure, consists of two distinct parts, the one a continuation of the chorion and vessels of the embryo, the other a continuation of the membrana decidua and vessels of the uterus. From the chorion, for instance, dendritic processes or elongations are sent out, which in small ova about a month old are so small and simple, that they are called villi, but which grow by and by into large and numerously divided stems and branches. Into each of these dendritic processes of the chorion there penetrates a branch of the umbilical artery, and a branch of the umbilical vein. Both vessels divide into branches in the same manner as the process of the chorion in which they run. At the extremities of the branched processes of the chorion, the divisions of the umbilical artery come together in loops or coils; these coils, however, are for the most part not simple; the same capillary winds several times hither and thither, and forms several loops; loops are also frequently formed by the anastomosing of two neighbouring capillaries. From these convolutions and loopings of the capillaries, little thickenings or enlargements of the extreme divisions of the processes of the chorion are produced. Each particular trunk, with its divarications of the shaggy chorion, forms a lobe or lobule of the placenta, which is covered by the tunica decidua. To this investment many of the terminal branches of the chorion will be found to have grown. It is in the spaces between the divarications

be viewed otherwise than as fragmentary, still bear so striking a resemblanee to the evolution of the mammalia and birds, that the

of the chorion, that those vessels run which transmit the blood of the mother, and which are prolongations of the uterine arteries and veins; they penetrate in this way to every the most minute lobule of the chorion. 4th. The object of this structure seems to be that the minute, convoluted, greatly elongated, and extremely thin-walled capillaries, in which thc blood of the fœtus is circulating, may be brought into the most intimate contact possible, with the larger but everywhere excessively thin-walled canals, in which the blood of the mother is flowing, that the two currents, without interfering with each other's motion, may pass each other to as great an extent as may be, with nothing interposed but the delicate parietes of each set of vessels; that they may exert an influence one upon another, the blood of the mother abstracting matter from that of the fœtus, and the blood of the fœtus taking, in its turn, matter from that of the mother. Eschricht differs from me in this, that he believes the uterine arteries and veins distributed to the placenta are connected together by as delicate, or even a more delicate system of capillaries, as that of the umbilical arteries; and in such a way that two systems of capillaries, that belonging to the child to wit, and another to the mother, are brought into intimate contact. I, on the other hand, believe I have demonstrated that the uterine arteries and veins, once they have entered the spongy substance of the placenta, do not farther divide into branches and twigs, but immediately terminate in a network of vessels, the canals of which are of far too large diameter to permit them to be spoken of as capillaries, and of which the parictes are so thin, that they cannot be shown apart by the most careful dissection. This vascular rete, which connects the uterine arteries and veins with each other, completely fills the spaces between the branched divisions of the chorion, and the extremely thin parietes of the canals of which it is composed, insinuate themselves at all points into the most intimate contact with the branches and convoluted masses of the capillaries of the umbilical system of vessels. This network of vessels, however, with reference to the passage of the uterine arteries into the uterine veins, performs the same office as a rete of true capillaries, so that it may be regarded as a rete of colossal capillaries. Eschricht maintains that plicated processes of the decidua penetrate the placenta, and may be traced bctween the branched divisions of the chorion, furnishing the several twigs with a delicate investment, and that these plicæ are the supporters of a capillary rete, by which the uterine arteries and veins are connected in the placenta. I, on the other hand, maintain that the walls of the uterine arteries and veins, where they penetrate the placenta, consist of a very delicate tunic, a prolongation, as it seems, of the inner tunic of the vessels of the uterus, covered with a layer derived from the substancc of the decidua; that the inner tunic of the blood-vessels lines the interspaces between the divisions of the shaggy chorion, and that the little masses of convoluted vessels or villi, which terminate the branches of the chorion, penetrate the canals which transmit the blood of the mother, and are bathed by it in their intcrior. In my mode of stating my views, I must, I fear, have left room for misapprchension, as I could perceive in the course of my conversation with Eschricht, that I had not bccn understood in the way I intended. I have not, I imagine, cxplained with sufficient clearness what I mean by *villi that penetrate the vascular canals of the mother.* This deficiency I

account of the development in these classes of animals may be assumed as affording unobjectionable data in regard to that of man;

take occasion to supply here. I do not then understand by villi entire stems of the chorion with all their subdivisions, as they appear when they are torn forcibly out of the placenta, but small projections or elevations that occupy these in points, or occur over every part of the stems and branches, and are formed by the terminal loopings and communications of the embryonic placental capillaries. Magnifying glasses are required to perceive these proper villi distinctly. In the second place I have said: 'the vessels of the uterus that penetrate the placenta become wider when they have entered it.' This expression is objectionable, at least in reference to the veins of the fully developed placenta, and I would therefore recall it." Weber then goes on to describe the structure of the placenta particularly, comparing it with the *corpus cavernosum penis* s. *urethræ*, or with an ordinary sponge. "The fibrous tissue of the sponge," he continues, "corresponds with or represents the branching subdivisions of the chorion and their uniting medium derived from the decidua; the cavities and interspaces of the sponge, however, represent the passages in which the blood of the mother flows. None of the many tortuous arteries which penetrate the decidua, still dividing into branches, from the uterus, when they reach the placenta undergo any farther subdivision; they open at once into the spongy texture, and are lost as ordinary vessels. Neither do the veins show any thing like division into branches; they all open like the arteries into the spongy substance of the placenta, by orifices larger or smaller. It is only as they are running in the investing decidua that they divide into a few branches. The spaces between the branched subdivisions of the chorion are thus kept filled with blood constantly poured in by numerous and large arteries, and regularly carried off again by numerous and capacious veins, so that it is perpetually renewed." Weber now details the grounds of his conclusions, which rest on injections of the uterus and other parts of women who have died in their pregnancy, on researches made on the recent after-birth, and on the study of smaller and fresh human ova. He remarks, among other things, that "if the uterine surface of a very fresh placenta, that has not been put into water, be moistened with a strong solution of corrosive sublimate in alcohol, in order to coagulate and prevent the escape of the blood still contained in it, and the whole placenta be then soaked in a weaker solution of the same kind, the whole of the maternal blood that remained in the spaces between the divisions of the chorion will be found coagulated; even in the larger lacerated veins that have just passed from the uterus into the placenta, coagulated blood will be found; and the manner in which these veins open into the interspaces mentioned, will be seen, and the course of the maternal blood during life be found indicated." Weber's observations on the structure of the placenta in the Mammalia are also extremely interesting; but as they extend to a considerable length, and a notice of them has already appeared (in Froriep's *Notizen*, Oct. 1835), I shall not enter upon them here. The placentas of all animals seem referable to two grand classes: "But the nourishment of the embryo appears in every case to depend on the subdivision of the fœtal and maternal blood into innumerable currents, the fœtal blood being however subdivided much more minutely than that of the mother, which pass each other through a great extent of tube, and are in contact through a like or still greater extent of surface, but always

with the materials drawn from thence, we may, without any risk of real error, attempt a connected sketch of the entire subject.

without the stream of the one interfering with that of the other, and without any admixture of the blood of the mother with that of the fœtus. These currents are

Fig. CXX.

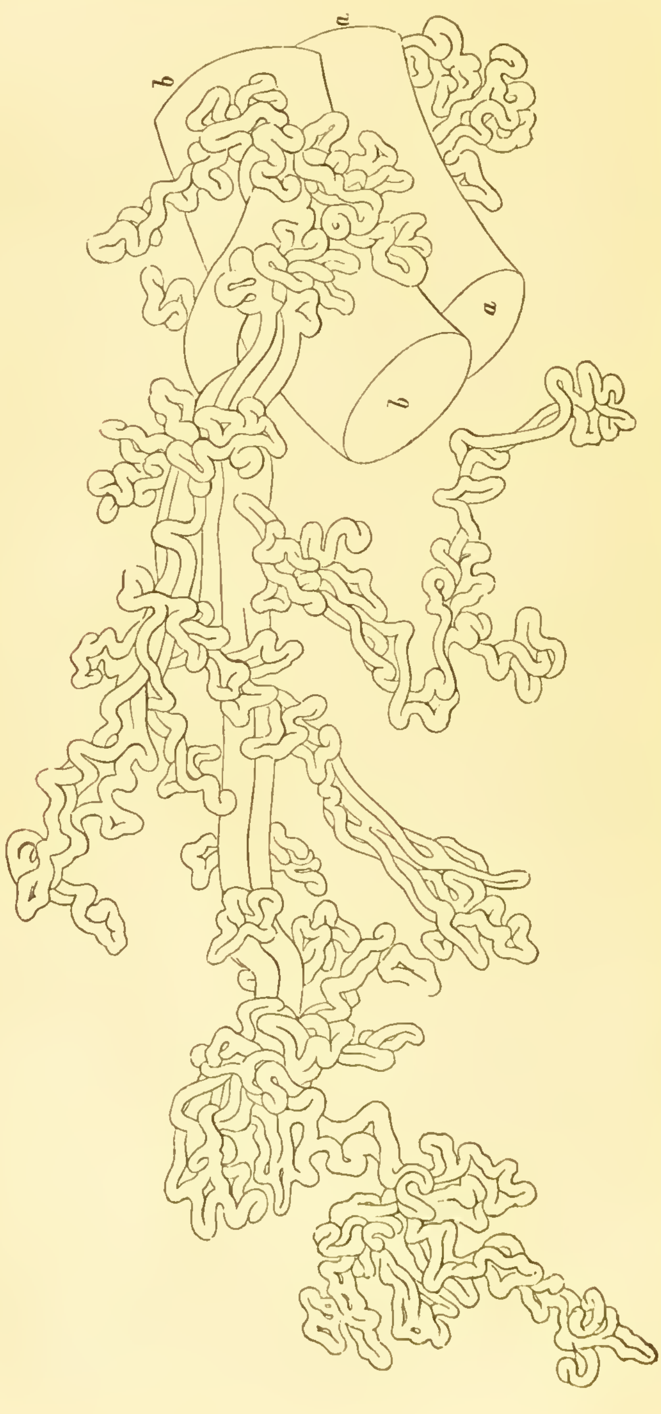


Fig. CXX.—Villi from the fœtal portion of the placenta, at the full time. The capillary vessels are filled with injection; their diameter varies from the $\frac{1}{115}$th to the $\frac{1}{170}$th of a Paris line. The preparation is dry, and is seen magnified about 100 times: *a*, the artery; *b*, the vein. The drawing communicated by Dr. E. H. Weber, of Leipzig.

The structure of ovarian ovum, and of the Graafian vesicle, the formation of the corpora lutea, are in man precisely as they are in animals; so that there can be no doubt of the ova quitting the

in fact separated from each other at every point, by parietes of extreme thinness, which, however, do not oppose all interchange of matters, these transuding or making their way through the delicate bounding membranes." Baer (*Entw.* S. 279) says : " By the growth of the vessels of the uterus into the decidua serotina, this is transformed into the placenta. That vessels pass from the walls of the uterus into the placenta is a fact long known and admitted ; but in regard to the form and mode of this passage or transference, opinions still vary. It was long believed, with Hunter, that they passed into cavities. In more recent times there appeared a growing disposition to regard these spaces as enlarged veins with extremely thin walls, a structure which is assigned to them among others and particularly by E. Weber. Very lately, however, Dr. R. Lee has very emphatically insisted, that the great veins of the uterus ended open-mouthed on the inner surface of that organ, but that these openings were closed by the substance of the tunica decidua, and that generally no other than vessels of very small calibre penetrated the decidua from the uterus. I myself used to view the matter as Weber has represented it; and since the statements of Lee, I have had no opportunity of appealing to nature for a solution of the question." I have myself discovered a very easy and simple method of procuring satisfaction, in regard to the structure and course of the embryonic vessels, without the assistance of any sort of injection. Let the smallest possible piece or lobule be removed by means of scissors, or forceps, from the uterine surface of a fresh placenta (which must by no means have been macerated in water), immediately under the delicate covering of the decidua, and this, covered with a delicate plate of glass, be brought under the microscope. The villi of the chorion will be seen full of the vascular coils of the embryonic vessels injected with blood (figs. CXIX. and CXXI.). These vessels are all of considerable size; I found them from the $\frac{1}{100}$th to the $\frac{1}{120}$th of a line in diameter, often nodulated as in the Malpighian bodies of the kidney ; the flocculi of the chorion surrounded them more or less closely, but sometimes so loosely (fig. CXIX.), that a clear crystalline space remained between the walls of the vessels and the bounding membrane of the villi, which were about the $\frac{1}{300}$th of a line in diameter, and showed on their edges a granular or cellular structure. Some vessels I observed much finer than the generality, not more than from the $\frac{1}{200}$th and $\frac{1}{250}$th of a line in diameter (fig. CXXI.) ; and in

Fig. CXXI.

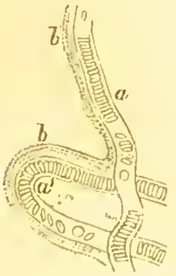


Fig. CXXI.—Vessels of the same part of smaller diameter, examined in the same manner. The vessels, *a, a*, the parietes of which are especially distinct at a^2, are seen thickly filled with blood globules, which lying face to face form columns ; *b, b*, edge of the villus, here lying close to the vessels in their course ; the vessels measure the $\frac{1}{200}$th of a line in diameter.

ovaries, descending along the Fallopian tubes, and reaching the uterus precisely as in the mammalia (§ 69). With simple analogy for our guide, we may conclude that the ovum reaches the extremity of the tube between the eighth and fourteenth day. The uterus at this time is already lined with the tunica decidua (fig. CX. *c*). If the ovum (fig. CXI. *g*) now passes from the orifice of the tube (fig. CXI. *b*) into the uterus, it will, as a general rule, glide between the wall of the uterus and the tunica decidua, push this away from its connexions with the uterus, and carry it forwards or inwards (*e*, *e*), by which the decidua reflexa is formed. The ovum now hangs within a sort of pouch into the (fig. CXI. *d*, enlarged) internal cavity of the uterus, which diminishes in extent with the growth. The cavity of the uterus is usually open at this period, the cervix uteri (fig. CX. and CXI. *a*) not being as yet closed up by its plug of gelatinous matter (§ 77). As soon as the ovum has reached the cavity of the uterus, it must grow rapidly by attracting matter from the fluids around it, and soon become readily visible to the naked eye; the granular disc about the chorion is resolved; the chorion itself has expanded and become thinner (CXXII. *a*). The vitellary ball (*b*) appears to be completely

these the globules of the blood presented a very beautiful appearance, the vessels being but of a diameter to a single row, so that they were arranged in parallel columns. The hem or margin is seen running close to the vessels (fig. CXXI. *b*). With regard to the maternal vessels, I could not make out anything clear or satisfactory. Von Baer's congratulatory address to Soemmerring, which treats "Of the vascular connection between the Parent and Embryo" (*Ueber die Gefässverbindung zwischen Mutter und Frucht*) Lips. 1828, fol. may be referred to for farther information on this subject. [Dr. Lee's paper, "*On the Structure of the Human Placenta and its connexion with the Uterus*," will be found in the *Phil. Trans.* for 1832. This zealous inquirer has seen reason to alter his opinions there stated. He now admits that the maternal blood enters the cells of the placenta by the tortuous arteries in the decidua, and is returned into the uterine veins by oblique openings in this membrane. R. W.] Ritgen's work, "*Contributions to illustrate the mode of connexion between the human Embryo and the Uterus*" (*Beiträge zur Anfhellung der Verbindung der menschlichen Frucht mit dem Fruchthälter*, &c.) Lips. and Stuttg. 1835, fol. does not advance the subject beyond the degree in which it was already known.

FIG. CXXII.

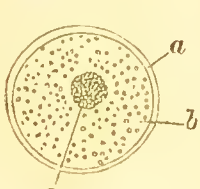


Fig. CXXII.—Human ovum, which had reached the uterus, greatly magnified. The external tunic *a*, surrounds the internal vesicles, the vitelline, to wit, and the germinal, *b*, upon which an aggregate of granules, *c*, the embryonic spot, indicates the point of formation of the future embryo. Vide fig. LXV. in the dog.

grown round by the blastoderma or germinal membrane, betwixt which and the chorion a thin layer of albumen appears now to have been deposited (§ 70); the vitellus has become more diffluent, and a round pretty thick granular cumulus, which is to be regarded as the central part of the blastoderma, has been formed. Of these particulars, we derive our information from the dog and the rabbit (§ 70, and figs. LXV—LXX); and there can be no doubt but that matters go on precisely in the same manner in the human subject. In the perpendicular section (fig. CXXIII.) of the ovum at this period, *c* would be the thickened granular cumulus, from which the development of the embryo commences. This granular mass will become clearer in the middle with the progress of the development; and, as in the bird (§ 50, and tab. CXI. figs. XXV—XXVIII.),

Fig. CXXIII.

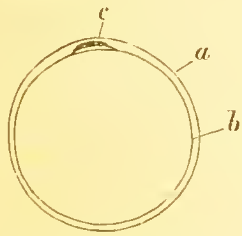


Fig. CXXIII.—Perpendicular section of an ovum similar to that of last figure but somewhat longer: *a*, chorion; *b*, vitelline vesicle (vitellus); *c*, the serous lamina of the germ.

Fig. CXXIV.

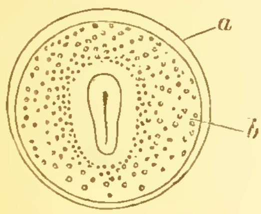


Fig. CXXIV.—An ovum still farther advanced. The embryonic spot is thinner and more transparent. Within the oval area vasculosa is situated the pyriform area pellucida with the nota primitiva in its middle; *a*, chorion; *b*, vitellus. Contrast the appearances presented by the embryo of the fowl, fig. XXV. and XXVII. and in the dog, fig. LXXII.

Fig. CXXV.

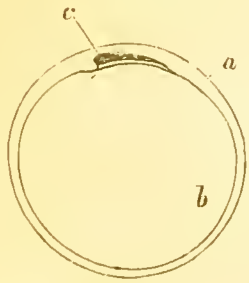


Fig. CXXV.—Perpendicular section of the ovum of last figure: *c*, lamina serosa.

and in the dog (§ 71, and figs. LXXI. and LXXII.), an oval form of blastoderma ensues, in the middle of which lies the transparent pyriform area proligera with the primitive streak (fig. CXXIV.). In the circumference of this the area vasculosa is developed, and the vitellary globe or mass (*b*) now completely enclosed by the blastoderma, has detached itself to a greater extent from the smooth chorion (*a*). The rudiments of the embryo (fig. CXXV.) are seen as a thickening of the serous layer (*c*), which is now parting from the underlying mucous layer. Analogy with the embryo of the bird and quadruped leads us to infer that the formation of the serous envelope and of the amnion (fig. CXXVI.) in the human subject proceeds exactly in the way we have found it to do in these lower animals (§ 56), and that the embryo (fig. CXXVI. *c*) is surrounded by a cranial (*d*) and a caudal involucrum (*e*), precisely in the same way; by this development of the peripheral portions of the serous layer, the embryo, which is becoming more and more strongly curved, is pinched off in a greater degree from the vesicle or umbilical vesicle (*b*); the vascular and mucous layers (fig. CXXVI.) are to be distinguished as superimposed laminæ in the abdominal cavity,

Fig. CXXVI.

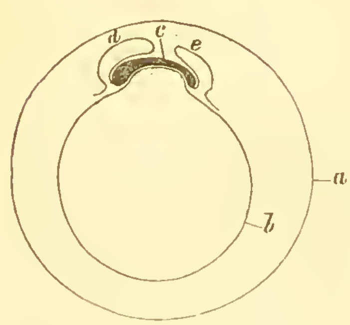


Fig. CXXVI.—Human ovum still farther advanced. Perpendicular section. The embryo *c* is curved in a greater degree, and is formed of the three laminæ of the germinal membrane; the vitellicle, the future umbilical vesicle, *b*, begins already to be pinched off, as it were, by the convergence of the opposite ends of the embryo; the amnion and serous lamina form the involucrum capitis *d*, and the involucrum caudæ *e*.

Fig. CXXVII.

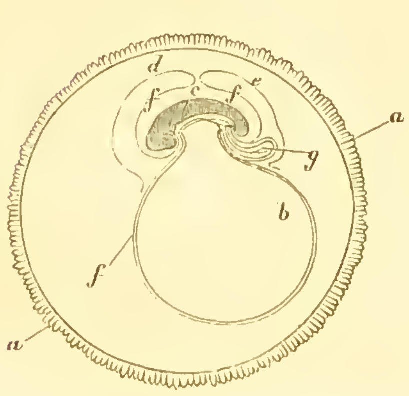


Fig. CXXVII.—Human ovum still farther advanced. The chorion, *a*, *a*, has now produced villi in abundance; the umbilical vesicle, *b*, is grown over by the lamina vasculosa *f*; from the embryo *c*, the amnion *f*, *f*, and the lamina serosa *d*, *e*, are detached, and meeting over the back of the embryo they will soon coalesce. The allantois, *g*, has been produced, and is covered with vessels.

the latter having at an earlier period completely overgrown the vitellicle. At a later stage in the development (CXXVII.) the villi become more conspicuous as formations sprouting from the outer wall of the chorion (fig. CXXVII. *a*); the serous envelope (*d*, *e*) rises from the amnion (*f*, *f*) whilst the two folds composing the involucrum of the head (*d*) and the involucrum of the tail (*e*) meet and grow together; the vitellicle or umbilical vesicle (*b*) is surrounded by the vascular (*f*) as well as the mucous layer. In the cavity of the abdomen, the rudiments of the principal viscera have now been formed by the extension and folding in of the two layers; the allantois (*g*) has pushed forwards betwixt the amnion and serous layer; the embryo is still more strongly bent, and still farther separated from the vitellus. The albuminous space within the chorion has enlarged greatly. As soon as the serous layer (fig. CXXVIII. *h*) is completely detached, it is pushed in the albuminous space against the inner wall of the chorion by the increasing amnion (*f*), and there apparently forms, in part at least, the tunica media, as it is entitled; the arachnoidal tissue of the albuminous space is also to be regarded as partially composed of coagulated albumen (§ 78. Annot. 156). The amnion is developed at an early period in the human subject, and soon surrounds the embryo in the guise of a capacious bag. On the chorion the villi become concentrated, as it were, towards a particular spot (*k*, *k*), and here the placenta is by and by formed; other places, on the contrary, become smooth (a^1), or are covered with shorter villi (a^2). The allantois (*g*) has now acquired the form of an elongated vascular sac, and is applied to the chorion—it has indeed at this period completely grown to the chorion; it is only represented as it ap-

Fig. CXXVIII.

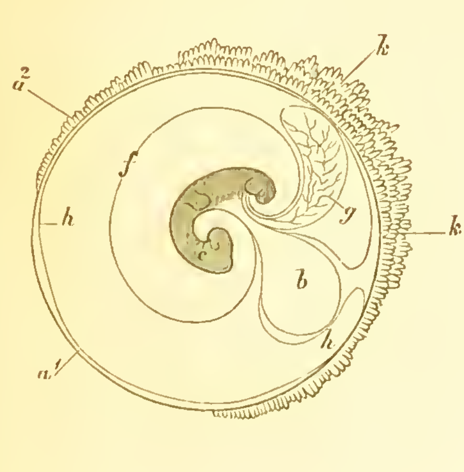


Fig. CXXVIII. — The human ovum in a state of still greater advancement. The chorion is now smooth at one part a^1; elsewhere it is villous, especially about *k*, *k*, where the placenta will be formed; the amnion, *f*, already surrounds the embryo, *c*, in the guise of a spacious bladder; and the serous envelope, *h*, *h*, has become applied to the inner aspect of the chorion; the allantois, *g*, is at the same time applied to the chorion, and the umbilical vesicle, *b*, is now smaller, and its neck becomes narrower and longer.

pears in fig. CXXVIII. *g*, for the sake of making the structure plain. The vitellus (*b*) has at this epoch become a pediculated pyriform vesicle—the umbilical vesicle, upon which the vessels have shrunk; the head of the embryo (*c*) is now found to have sunk greatly downwards in almost all ova. At the beginning of the third month (fig. CXII.) the os uteri is seen filled with a consistent gelatinous plug (fig. CXII. *a*): over the os uteri the decidua vera is generally wanting; it lies close to the walls of the uterus (*c, c*), sends out on that side where the ovum has not entered, shorter or longer processes (c^2) into the orifice of the Fallopian tube (*b*); but here too it is frequently perforated or absent (§ 77); the decidua is deeply inverted or involuted by the ovum (fig. CXI.), so that it is only inferiorly (*d*) that there still remains any space between the decidua vera and decidua reflexa; the edges of the involution (*e, e*), the circle where the true and the reflected deciduæ pass the one into the other, can be followed; the interval that was produced by the separation of the decidua becomes filled with a new exudation (*f*), and in this way is the decidua serotina formed; at this part also the villi of the chorion are additionally evolved by the pressure of the allantois (*g*) upon them. The allantois terminates in the urachus and bladder; near the urachus lies the pedicle of the umbilical vesicle (h^2) in the umbilical cord; the umbilical vesicle itself (*h*) is included in the space betwixt the amnion and chorion; through the compression of the albumen, the membranous stratum (i. e. the tunica media united to the serous covering) is readily demonstrable as a distinct coat.

CHAPTER III.

OF THE DEVELOPMENT OF THE TISSUES (HISTOGENY).

Materials.

§ 83. In our exposition of the development of the chick, and account of the human embryo, a merely general and relative view of the morphological changes undergone has been taken; not to interrupt the narrative, the mode in which the tissues originate (histogenia), and the doctrine of the intimate structure of these and of the organic parts at large (histologia), have been only touched upon by the way, and incidentally. In the present chapter, it will be our business to make good these deficiencies.

The knowledge we possess in regard to the earliest formations of the tissues has been especially derived from the study of embryos of the mammalia and man, recourse being, at the same time, had to the incubated egg, more particularly during the earlier periods of its transformations [168].

Structure of the germinal Membrane (Blastoderma).

§ 84. So soon as the germinal membrane is formed in the hen's egg, a change or metamorphosis is seen to have occurred in its constituent globules or cells, which, even in the sixteenth hour of incubation, show a difference of form in the serous and mucous lamina. In the *serous* stratum, the cells tend to protrude outwardly, in the form of hemispheres, and by pressing closely one upon another, they acquire the appearance of six-sided figures (fig. CXXIX.); each cell contains a distinct nucleus, in contact with the inner aspect of its walls, of a round shape, and itself showing one or two nucleolar molecules; the cells are, moreover, distended with a transparent fluid, in which, however, small granules appear, which, still included in the cells, exhibit molecular movements. In the *mucous* stratum, the cells are particularly large, and, under the microscope, resemble little yolks, including granules and globules of very various dimensions (fig. CXXX.) One or more of these globules are larger than the rest, and show a darker contour; the other globules exhibit a finely granular mass having molecular movements, suspended in a transparent fluid. These cells or globules lie rather loosely together in a thick intercellular substance, but without visible structure, as their cytoblastema [169].

[168] Much information on the subject of histogeny will be found in Valentin's *Account of the Evolution (Entwickelungsgeschichte)*, and in the work of Schwann, already so frequently quoted, *Microscopical Investigation of the Accordance in Structure, &c.* Berl. 1838. In the paragraphs that immediately follow, I have preferred laying the observations of Valentin and Schwann before my reader, to using any of my own, my researches in histogeny being of too fragmentary a character, and not agreeing in every particular so entirely as I could have wished with those of the excellent observers mentioned, who have made this subject their particular study.

[169] The account just given is especially after Schwann (loc. cit. p. 65). Valentin, however, was perfectly well aware of the histological differences in the two laminæ of the blastoderma, and gives the dimensions of the globules, or cells as they are now regarded; those of the lamina serosa, which, by mutual compression assume the form of six-sided bodies, he compared to the cellular tissue of vegetables. In the spring of the year 1838, I observed the differences specified with great distinctness in the several laminæ of the germinal membrane,

Formation of the Blood and Blood-vessels.

§ 85. The earliest stages in the formation of the blood, and of the blood-globules and vessels, are extremely difficult of observation; and no one of the many who have given their especial attention to the earliest stadia of evolution generally, has succeeded in completely following the process of their evolution through all its stages. As we have seen, the formation of the blood in the embryo of the mammal, bird, and frog, occurs at a very early period. The cells which lie between the serous and mucous lamina of the blastoderma comport themselves in a peculiar manner in the chick, even

represented in fig. XXVIII., and made drawings of the appearances in the three strata *b*, *c*, *d*. The globules or cells of the mucous lamina appeared to me precisely as Schwann has figured them; in the serous lamina, however, I was only aware of the existence of small granules, probably the nuclei of the cells, overlooking their envelopes. At this time, Schwann's researches were still unknown to me; at the present moment (Nov. 1838,) I have no opportunity to examine the subject anew.

Fig. CXXIX.

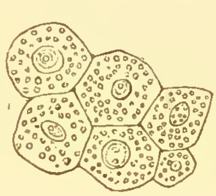


Fig. CXXX.

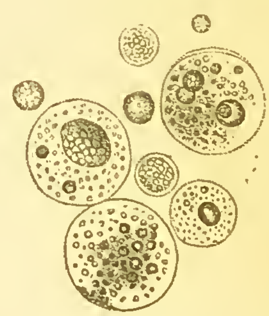


Fig. CXXXI.

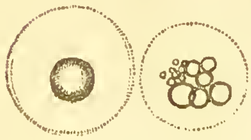


Fig. CXXXII.

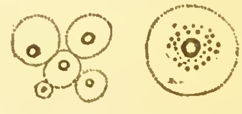


Fig. CXXIX.—Cells of the lamina serosa of the blastoderma, with their nuclei. Fig. CXXX. cells and globules of the lamina mucosa. Fig. CXXXI. globules of the vitellus. Fig. CXXXII. globules of the thinnest part of the vitellus from the central cavity of the part. These figures illustrate the cellular structure of the blastoderma and vitellus, according to Schwann, (see his microscopical investigations of the accordance in structure, and mode of growth among vegetables and animals, tab. ii.)

so early as the 20th hour from the commencement of incubation; they appear to be very loosely conneeted, and form a spongy lamina, whieh seems to imbibe a great deal of moisture, derived prineipally, as it would seem, from the eentral eavity of the vitellus, and the eanal that aseends from it to the germinal membrane (§ 47, fig. XVI. *i*, *k*, p. 47). A certain proportion of the globules or eells appear to be transformed into blood-globules; perhaps the nuelcus of the eell affords the rudiment of the nueleus of the blood-globule, for this is extremely distinet at the very earliest periods; the blood-globules too of the embryos of both animals and man are, for some eonsiderable time, notably larger than those of the adults of the several kinds. Another portion of the eells or globules of the vaseular lamina, by beeoming applied to one another form the parietes of the blood-vessels. The walls of the heart in the chick, towards the end of the second or beginning of the third day, ean be seen to be eonstituted by a union of many polyhedral eells, eaeh of whieh presents a darker spot in its middle, undoubtedly the nueleus of the pre-existing and unconneeted eell (fig. CXXXIII.). In a precisely similar way are blood and blood-vessels formed in the periphery, as in the eentre. The blood, at first, is eolourless, but it begins to aequire eolour so early as the end of the first, or beginning of the seeond day, at whieh period it may be seen moving in eireumseribed vaseular ehannels, under the influence of the undulatory aetion of the heart[170].

[170] The formation of the blood will be treated at greater length by and by; here I have only given the most general and essential points, after my own observations; the results of the researches of Pauder, Baer, Valentin, Baumgärtner, Reichert, and others, will be stated in the Second Book of this work, which treats of Nutrition. On the singular difference in the size of the blood-globules in young embryos and adult individuals of the same kind, first observed by Dr. E. H. Weber and myself, see my *Contributions (Beiträge, &c.* 2tes. Heft, S. 35). This difference deserves mention in this place, as it affords a new assurance against the existence of any direct communication between the vessels of the mother and those of the embryo.

Fig. CXXXIII.

Fig. CXXXIII.—The heart of the embryo of the fowl, end of the second day, greatly magnified. The cellular structure of the parietes of the organ is apparent; each tessellated cell has its nucleus. The several divisions of the heart are also already indicated; *a*, the atrium; *b*, the ventricle; *c*, the bulb of the aorta.

Origin and Evolution of the Tissues.

§ 86. The present state of our knowledge of the histogenesis, or doctrine of the formation of the tissues, renders it probable, that all the tissues result from metamorphoses of the primordial cells of the germinal membrane and vitellus. The first indications of histological difference appear in the three laminæ of the germinal membrane, which then immediately afford the elements of all the succeeding tissues. The structure of these tissues will fall under consideration by and by, in the particular appropriate sections of the different books of this work; in the following annotations, the history of the development of the several tissues will be found sketched in general and broad outlines.

Professor Valentin at my request has furnished me with a general survey of the subject of histogeny, which I communicate here entire, and as it came into my hands.

PRINCIPAL FEATURES IN THE DEVELOPMENT OF THE ANIMAL TISSUES, BY G. VALENTIN.

In my first histogenetic inquiries, I observed certain peculiar granules embedded in transparent gelatine, as the elementary matter of all the tissues. I remarked the difference between these granules in the serous and mucous laminæ, at the period of the earliest separation of these layers from one another. In the vascular lamina I found large globules or cells, which in form and mode of mutual apposition I likened, so long ago as the year 1835, to the cellular tissue of vegetables (*Entwickelungsgeschichte*, 287). I also first directed attention to the resemblance in form and appearance of the cartilages beginning to be ossified, particularly of the branchial cartilage in the larva of the frog (from observations made in conjunction with Purkinje), to the cellular tissue of plants (*ib.* 209, 210). I described the round cells of the globules with their interposed cellular substance, of the chorda dorsalis of young embryos (*ib.* 157, and *Repertor.* i. 187). Shortly after this, I. Müller, from his own independent observations, announced the cellular structure of the chorda dorsalis of fishes (on the *Myxinoids*, 74). In the Epithelium, which Purkinje and Raschkow (*Melet. c. mammal. dent. evolut.* 12), as well as myself (*Nov. Act. Ac. N. C.* vol. xviii. p. i. 96), compared to the cellular tissue of plants, I chose, expressly on account of this resemblance in form, the same designation for the central mass, viz. nucleus, just as I subsequently described the nucleolus which was observed by me at a later period (*Repertor.* i. 143). In the study of the Epithelium continued particularly by Henle and me, the analogy to the cellular tissue of vegetables could not be missed, and the independence of the cellular parietes was distinctly indicated (*ib.* i. 284). I had also seen that the nuclei were the parts first formed in the pigment of the choroid coat of the eye (*Entwick.* 194), and I compared the pigmentary cells to the vegetable cellular

tissue (*Repert.* 245, *Langenbeck, de Retina,* 38). Schwann gave undoubted completeness to these analogies when he showed that the gelatinous primordial mass of the tissues was composed of cells, that the granules or bodies embedded in it are nuclei, and that these often exhibit laws of evolution of the same kind as the cells (Frorieps, *Neue Notizen,* Heft i. 3, 1838, and *Micros. Untersuch. über. Einstimmung,* &c.) In 1837, I had observed the cells of the germinal membrane in the ovum of the Sepia, with their nuclei and nucleoli, and the areas that surround them, and made known my observations in a letter to Breschet. Very shortly after I became acquainted with Schwann's first paper (Frorieps, *N. N.* 1838), I began a series of observations on the subject; and the chief results of these my more recent investigations form the matter of the following communication. I have at the same time referred at the proper places to Schwann's "Inquiries" (*Untersuchungen,* &c.), the first part of which I have this day received.

As among vegetables so among animals we find granular nuclei, including one or more nucleoli and surrounded by more or less independent cells, which consist of separate bounding parietes, and distinct contents. From this primordial formation proceed all the tissues, how heterogeneous soever they appear in their completely elaborated and perfect estates. The different ways by which the metamorphosis happens are susceptible of arrangement in an ascending series, under the following elementary types :—

I. *The nuclei with their nucleoli, which at an earlier stage are free, surround themselves with a clear cell, which however soon dissolves, so that the nuclei swim about as characteristic corpuscules in the fluid, and there and as such advance in their individual development.* In the normal organism this is what happens in regard to the *Blood,* and probably also to the *Lymph.* The blood-globules are not cells, but nuclei. Their nuclei are in effect nucleoli. This view is vouched for by two decisive facts:—1. In the larvæ of frogs we see plainly round or square shaped granules, applying themselves around the nucleoli (*Enwickelungs-gesch.* 297. Wagner, *Beiträge,* Heft ii. 38), and by and by transforming themselves into a homogeneous shell, whilst the nucleus remains. This is the type of the mode in which the nucleus universally originates, and attains its development, whilst the cell around the nucleus appears without exhibiting any transition-stage of the kind. 2. When the blood-globules of the embryo, even after they have attained the flatness that characterizes them in the mammalia, and agree in size with those of the mature animal, are treated with acetic acid, they suffer little or no change in form and size; whilst this acid immediately reacts in the well-known manner upon the fresh blood of the mother. The blood-globules of the embryo thrown into concentrated acetic acid first lose their colouring matter, although in a less degree than when treated with distilled water, and they retain their shell or envelope for two days or more, either crisped or altogether unaltered. Now insolubility in acetic acid is a general character of the nuclei of the blood-globules, whilst the cells and the products of their metamorphoses are universally attacked in a greater or less degree by the acid in question. The bodies called the lymph-granules of the blood, are in all probability free nucleoli, which gradually surround themselves with nuclei. Among the products of pathological states, exudation corpuscules [coagulable lymph granules] belong to this category. Like so many embryonic nuclei these are round, granular, and lie tessellated one upon another, whilst their very small interstices contain a transparent gelatine. Should the exudation become purulent, this gelatine acquires fluidity, and the pus globules then swim in the liquor

puris, sink tessellated to the bottom, and surround themselves with cells, which subsequently undergo transformation in accordance with the laws immediately to be named into exudation-fibres or exudation-membranes.

II. *The nuclei surround themselves with cells which are permanent, but various metamorphoses of both the nuclei and cells ensue, according to the individual character of the tissues and parts which they go to compose :*

(*a*) Epithelium.—In the *Cellular Epithelium* the cells are more or less polygonal, flat, and lie tessellated or pavement-like near one another. The parietes become (from secondary deposition ?) granular and horny. The nuclei grow smaller, clearer, often smooth, and lie here centrally, there excentrically; finally, the nucleus often becomes attached to the inner aspect of the wall of the cell. In the *cylindrate epithelium* the uppermost and oldest cell is cylindrical, and its free superior surfaces are either level or slightly convex, its opposite aspect appearing more pointed, and produced into a filament. In the *ciliate epithelium* the free upper surfaces of the cells are beset with cilia, only on their edges however, not on their middles. The nuclei are clear, and when the tissue is treated with water they often present themselves between the cilia, or where these have fallen off they look like clear globules (*Nov. Act. Ac. N. C.* vol. xvii. p. ii. tab. lxv. fig. 3). All the cylindrate and ciliate epitheliums show a longitudinal perpendicular arrangement of cells (*Repertor.* iii. 310).

(*b*) Horny tissue.—As the best example of the horny tissue, I select the hoof of the mammal. The nuclei in this tissue are in the first instance, both relatively and absolutely, large, opaque, round ; the cells are relatively small, transparent, and without obvious constituent molecule in their parietes. By and by, both the walls and the contents of the cells expand conspicuously, without losing their half-polyhedral, half-round, characteristic boundaries. The more the cells dilate, the more do the nuclei shrink, and they finally present themselves to the observer as very elegant round corpuscules having one nucleolus, and in extremely rare instances several nucleoli, in their centre. The nuclei from the peculiarity just mentioned and their flatness finally bear the closest resemblance to the blood-globules; they are attached, generally excentrically, to the inner aspect of the parietes of the cells. These parietes are rough (from granules or laminæ applied to the inner aspect of the primary walls of the cells ?) and grow constantly more and more horny. The cells often exhibit a certain expansion lengthwise (hoof of the horse), at the same time that they become more transparent and more intimately connected, although here and there their boundaries, even in grown animals, are frequently still to be detected. On other horny tissues, vide Schwann, l c. 90—99.

III. *The cells exhibit metamorphoses, which in point of form are in all respects analogous to those we observe during the formation of the wood, and indeed of the pores, in plants.* (Burdach, *Physiol.* 2 Aufl. B. ii. 168.) At first there arises a polyhedrous cell, with a large opaque nucleus. This nucleus, however, is absorbed, and grows smaller in the same proportion as a deposit furnished with spiral canals takes place on the inner aspect of the wall of the cell. The primary wall of the cell is at all periods readily to be distinguished. The canals in neighbouring cells correspond with one another. The tubular membrane of the cray-fish, *Repertor.* i 124, tab. i. fig. 23, and in all probability the membrane of the enamel of the teeth, are formed in a similar manner.

IV. *The cellular element is extremely distinct in the earliest periods of its formation, but a secondary product obscures it, or even causes it to disappear entirely.*

(*a*) Fat (*adipose tissue*).—The cellular element is most advantageously examined in much emaciated subjects. If the integument covering the pectoralis major muscle be removed, and a very delicate slice of one of the small masses of reddish yellow-coloured fat, which will there be found lying immediately under the corion, be placed in the field of the microscope, a very beautiful series of polyhedral cells with distinct parietes will be brought into view. The periphery of the somewhat pale granular nucleus is generally distinctly visible. A large fat or oil globule occupies its centre, and around it, concentrically disposed but more or less scattered, a variable number of smaller fat globules. Large fat globules, with concentrically scattered smaller ones, and a surrounding transparent but definite cell, are conspicuous in the reddish yellow-coloured fatty mass which lies over the spinal cord of the calf. On the cells of the vitellus, vide Schwann, l. c. 56.

(*b*) Pigment.—I have already remarked that the nuclei (pigmentary globules) were the parts first formed here. These surround themselves with a cell, which generally goes on enlarging more and more, and is usually polyhedral. Around the nucleus, which looks clear in consequence, and from it outwardly, towards the inner wall of the cell, pigmentary molecules are disposed, whilst the primary walls of the cell continue parted, and, being so, polygonal interspaces are observed between their several layers.—(Vide the choroid coat of the horse's eye). Pigmentary ramifications arise in accordance with the law by which a cell passes into a fibre.—(Vide under VIII. *a*.)

V. *The nuclei surround themselves with extremely delicate cells, and about these a peculiar substance is deposited, which in its capacity of rapid growth soon forms the largest portion of the tissue, and in which, as in all other intercellular masses, new nuclei and cells may be produced.*

Imposed globules of the central and peripheral portions of the nervous system.—The process of development here is best observed in the grey substance of the superficies of the hemispheres The round granular nuclei, with from one to three generally round, rarely fusiform nucleoli, surround themselves with cells of the utmost delicacy, consisting of a transparent membrane and a limpid included fluid ; these, when treated with water, give way and disappear, no trace of them, save their nuclei, remaining ; they can actually be seen bursting, the fact being betrayed by the momentary jerk which the nucleus exhibits, the phenomenon being precisely the same as that which Schwann observed in the central substance of young ova (l. c. 57). By and by a substance of a grey or reddish-grey colour, and consisting of fine granules and a transparent uniting mass (a relation which is best seen when a fine slice from an entire —from two to seven inches long—embryo of the cow or sheep, is placed under the microscope without water and by lamp light), arranges itself around this cell. The cells and their burstings are also seen very distinctly, and in precisely the same way, in the granular layer of the retina. The nuclei of the ganglionic globular layers are brighter. In the ganglionic globules the process is analogous to that of the central apposition-globules (*Belegenskugeln*). The reddish-grey matter which is deposited around them is firmer, as it lies more inwardly. In the embryo of the sheep, measuring an inch and three-quarters, all the stages of the development may be seen in the Gasserian ganglion close to one another :—mere nuclei at one part, and at another very minute complete ganglionic globules, evolved at the expense of the external

reddish-grey, finely-granular substance, and which, despite their minuteness, are seen to be round, three-cornered, taper-shaped, and so forth, and generally flattened in a greater or less degree. In the clear nucleus, which is ever relatively the larger as the ganglionic globule is absolutely smaller, from one to three separate nucleoli are contained. On the farther development of the ganglionic globule, vide Müller's *Archiv*, f. 1839.

VI. *The cells exhibit a very high degree of productive or procreative power. New nuclei are perpetually arising within them and there surrounding themselves with cells, we have finally cell within cell, like a nest of pill boxes* (Repertor. i. 34, 175, 286, tab. ii. fig. 35) *; abundance of intercellular substance is at the same time deposited betwixt the parietes of the cells, and these two elements blended together compose the elementary mass,—the cells with their products, the nuclei aud nucleoli, the proper and peculiar corpuscules.* (Schwann, l. c. 26, et sequent.)

Cartilage.—This intercellular substance is more compact; it is granular in the permanent cartilages of the adult, and acquires its higher consistency and its earth in the process of ossification. During this there arise opaque, and by and by ossific reticulations, in the centre of which are seen clearer spaces, often separated by concentric annular striæ, containing cartilage corpuscules with simple or double-imboxed nucleoli. These cartilage-corpuscules pass immediately into bone-corpuscules (*Entwickel.* 263); clear at first, they become more opaque by degrees; they are of large size, push out at one or both points, especially in the first instance, filiform prolongations, which are the first indications of radii, and grow of a darker hue from the periphery towards the centre. When they are still clear but chemically impregnated with lime, their structure is no longer recognizable; if the slice be softened by an acid, however, the nuclei and nucleoli come again into view, in the same way as the numerous smaller bone-corpuscules present themselves in the spongy tissue which surrounds the medullary cavity concentrically, or lengthwise, especially in the bones of adults, and like other cellular fibres contain elongated nuclei with pretty clear, small, and separate granules. On the formation of the medullary cavities, vide *Entwickelungsgeschichte*, 261. In the reticulate cartilage of the ear, the round granular nuclei and the intercellular substance blend together and form a network which hardens and enlarges, and besides the clear cellular substance, contains in its meshes round nuclei, or true cartilage-corpuscules. By reason of the multiplied imboxing in cartilage, the indication of the elements, as cell, nucleus, and nucleolus, is to be viewed as merely relative. On the fibres of the dental substance, which Schwann (l. c. 74), with the greatest probability of being in the right, has referred to this place, my own observations are incomplete. The cells of the primary mass resemble those of the primary substance of the auricular cartilage (in the sheep), and the fasciculate canals seem the analogues of the cellular parietes, or of these and the intercellular substance.

VII. *The cells are tessellated, or spread out into a membrane, in the manner of a piece of pavement ; their granular nuclei lie in the middle. The parietes of the cells blend into a transparent simple membrane, whilst the nuclei are ever more and more absorbed ; becoming constantly paler, until at length they are no longer recognizable :*

(*a*) Hyaloid membrane; capsule of the lens; elementary membrane of the saccus capsulo-pupillaris.—In the first two of these tissues the nuclei are especially delicate; their extreme paleness soon renders them scarcely visible; by and by, as it appears, they vanish entirely.

(*b*) Inner membrane of the blood-vessels.—In both the arteries and veins of the embryo, as well as in the large vessels of adult animals (the horse), pale granular nuclei are conspicuous. The blending, or fusion of the cells takes place after the fascicular type, which will be immediately described; when detached they therefore usually present themselves as broad cellular fasciculi, evidences of their fibrous structure being readily discovered at every point of the membrana intima. (Müller's *Archiv*, 1838, 196.)

VIII. *The cells and their nuclei arrange themselves in longitudinal lines; the cell-walls coalesce in lines, and, at the cost of the nuclei, form themselves into fibres:*

(*a*) Cellular membrane.—The cells become elongated, coalesce longitudinally, and over and under the nucleus grow smaller, till at length they change into cylindrical fibres. The very delicate cell-paries is produced, or drawn out, over the nucleus, which soon becomes of an elongated round form, but somewhat flattened: in this way arise spindle-shaped bodies containing a granular nucleus, which extend as cylindrical fibres. The arrangement of the individual cell-fibres prefigures exactly that of the future cellular membranous bundles. They form reticulations, the meshes of which are round, and not unlike the cellular tissue of an herbaceous vegetable (*example*, in the connecting tissue of the navel string, and the pulp of a tooth); or they stand in simpler arches (*example*, in the epiploa); or they close in and surround organs and organic parts (*example*, the glands and the several lobules of these); or they are longitudinal (*example*, in the septa of the kidney, the transversely-streaked muscular fibres, upon the blood-vessels, and so forth). In general there proceeds from one of the two ends—and this is that one which is in relation with the nucleus—a simple cylindrical filament of the cell-wall. In the pulp of the teeth it forms with the delicate wall of the cell, a more or less three-cornered central body, from which several, generally three, threads diverge, an arrangement with which Purkinje and Raschkow (l. c. fig. 7) were already familiar. Finally, in the omentum majus of a fœtal calf, nine inches in length, I once observed several cylinders proceeding from the lateral aspects of a spindle of this kind, in addition to the two, one from either end, which are usually encountered. These spindles, with their nuclei, I first noticed in the sheath of the acoustic nerve (*Entwick.* 208). The spindles, with their nuclei, lie at those points where the fibres run longitudinally—straight or concentrically, alternately or severally, whilst the interspaces are occupied by a transparent mass. In reticulate connexions a transparent gelatine lies in the meshes, which in the umbilical cord often contain an isolated granular nucleus, or this included in a round cell. The nuclei are paler, and finally disappear completely, so that instead of a cellulate fibre, a simple fibre is formed, and this separates, in accordance with the laws of separation, into filaments of cellular tissue, which immediately after their acquired individual existence in their free condition, exhibit their elastic undulatory flexions—this is apparent in the sheep's embryo of two inches long. The fibres of the tendons comport themselves in a similar manner, only that here the fibres are thicker, and in the first instance present granular bundles.

(*b*) Elastic tissue.—The cells lie like parenchyma by one another, and are somewhat depressed or flattened, as it seems. Their walls are granular, at the expense of the nuclei, but not so dark as in the horny tissue. By the blending or fusion of these cells arise (in the ligamentum flavum nuchæ) peculiar granular

fibres, which are at the same time covered externally with small molecules. In relation with the parietes of the cells, or as intercellular substance, the elastic fibrous net is now produced, and this, from its thickness, raises and incloses between its meshes the smooth dry granular parietes of the cells—this is apparent in the aorta even of adult animals.

(*c*) Muscular tissue.—So soon as the muscular tissue assumes the fibrous form, it is seen to contain very pale round nuclei, lying in the close vicinity of one another. From this it is fair to conclude, that the cells, in like manner longitudinally arranged, blend together immediately, and without undergoing elongation into filaments. This inference is confirmed by the circumstance that such a muscular fibre in the embryo is seen as a mere succession of chambers, like a fibre of the ova of the confervæ, with its series of cells, and a nucleus in each. I have not hitherto, however, succeeded in obtaining such a view of this multilocular arrangement, as fully to satisfy my mind of its entire and constant accordance with nature. There are two conditions which either bring out the appearance, or render it plainer:—1st. It happens that betwixt each two of the ordinary constrictions of the muscular fibre a regular nucleus is perceived. 2nd. Upon the transverse lines which produce the cancellate divisions, lie very small round molecules, with very dark outlines and transparent centres, in a more or less regularly transverse lineal arrangement. The clear nucleus lies inside the hollow muscular fibre, and is frequently seen projecting, either partially or wholly, from the divided end of the fibre. At a later period it is ever more and more undistinguishable. Longitudinal striæ, and soon after these, transverse striæ, make their appearance in the muscular fibre. That the internal hollow of the muscular fibre remains, is rendered probable by the circumstance noticed by me, now some time ago, to wit, that the ends of the living muscular fibre divided, often become everted (Hecker's *Neue Annalen*, ii. 71). The subsequent stages in the development of the transversely-streaked muscular fibre are treated at length in *Entwickelungsgeschichte*, S. 69.

(*d*) Fibres of the crystalline lens.—That the superficial vesiculate or cellular formation suffers metamorphosis into the fibres of the lens, was shown by me to be extremely probable in 1838 (Ammon's *Zeitschrift*, iii. 330). The cells contain very pale nuclei, with single nucleoli; they then unite longitudinally one with another, like a string of beads, pale nuclei being still discernible inth e cells of most recent formation. Upon the fibres themselves I further observed an extremely delicate granular matter. Each fibre then divides by fine lines into threads, which however cannot be distinctly isolated, even in the adult, and which are remarkable for the beautiful regularity of their arrangement (*Entwick.* 203; Werneck, in Ammon's *Zeitschr.* v. 414).

(*e*) Primary nervous fibre.—The septa arise in the fibres of nerves like those of the muscles, ganglionic globules, and ganglia, glands, &c. out of cellulate fibres, from which the general sheath of a nerve in the first instance, and the special sheaths in the second, become distinguished. Within this sheath we can perceive, but only at a very early period (in the nervus trigeminus and nervus facialis of the sheep's embryo, 1¾ of an inch long, for instance), single primary nervous fibres, which here run as completely isolated as we find them in the pulpy nerves (*in nervis mollibus*) of adult creatures, which are, like these, rendered visible by caustic alkali (when they are not already obvious), and which from the greater relative strength of the sheath first become tortuous after mechanical

traction. The contents are not of a pure white colour, but decidedly yellowish, and the fibre occasionally exhibits a small clear (granular) nucleus in different places of its course. At a later period the fibre becomes white, and the more the sheaths are individualised, the more does it exhibit windings, and increase in breadth and thickness.

IX. Finally, the earthy deposits of the body manifest their cellular relationships in a less obvious manner. The auditory crystals present themselves in the sheep's fœtus of from six to seven inches long, as very small elongated round bodies. If a fine slice of the membranous labyrinth be examined, three or four of these crystals may be seen connected with a nucleus, like so many nucleoli. These minute bodies, even at this early period, when treated with a little nitric acid, give off an abundance of carbonic acid gas. The crystalline globules are laminated, or arranged in layers, around a nucleus (Müller's *Archiv,* 1836, t. x. fig. 13), or around this and a nucleolus (Remak, *Obs. Anat. et Microscop. de system. nervos. struct.* tab. ii. fig. 26; *Repertorium,* iii. tab. i. fig. 6).

From the account now given, it appears that we have an ascending series of formations, in which the types I. II. III. and IV. present perfect analogies with those that are observed in the vegetable world. Types V. and VI. are essentially modified, and appertain to the very highest grades of organic formation. Types VII. and VIII. possess the purely vegetable form only in the very earliest stages; in their perfect conditions they present no analogy whatsoever with any thing we observe in plants, in point of form. The transition stage of the cellular fibre may perhaps be found to present a certain analogy with what Mohl has described and figured in Scytonema myochrus (*Ueber die Verbindung der Pflanzenzellen,* 1835, tab. i. fig. 10), as also in the knotty vessels of the latex of young leaves—in Robinia pseudo-acacia, for example.

The universal primitive form of every tissue is therefore the CELL, which itself is preceded by the NUCLEUS as mediate, and the NUCLEOLUS as immediate products of the formative power. Cells and nuclei seem to stand in mutual and relative opposition, so that generally, perhaps invariably, the one is evolved at the expense of the other. After these transition stadia are accomplished, the tissue attains individuality according to general character and the place it occupies in the system. During this last stage the more distant organic parts enlarge, as is distinctly seen in the cells of the epithelium, in the tubular membrane, in the pigment, the ganglionic globules, the muscular fibres, the tendinous fibres, the primary fibrous fasciculi of the nerves, and the elastic fibres; whilst mere nuclei, such as the blood, lymph, coagulable lymph, and pus-globules remain, or suffer diminution in the course of further development.

That the cellular formation also forms the basis of all the morbid, new, or heterologous formations, is made manifest by the observations of Müller, Henle, and myself. [Vide in particular the work of Müller, *Ueber krankhafte Bildungen, &c.* for an excellent translation of which into English, *On the Nature and Structural Characteristics of Cancer, &c.* we are indebted to Dr. West. 8vo. Lond. 1839. R. W.]

After the above communication of Dr. Valentin was in the printer's hands, I received, through the politeness of Dr. Schwann, a brief notice of the results to which his OBSERVATIONS ON THE DEVELOPMENT OF THE TISSUES had led him; and it affords me

particular pleasure to have the privilege of laying these before my reader in this place.

"All the organic tissues," says Dr. Schwann, "however different they may be, have one common principle of development as their basis, viz. the formation of cells; that is to say, nature never unites molecules immediately into a fibre, a tube, and so forth, but she always in the first instance forms a round cell, or changes, where it is requisite, cells into the various primary tissues as they present themselves in the adult state. The formation of the elementary cells takes place, in the main points, in all the tissues according to the same laws; the farther formation and transformation of the cells is different in the different tissues.

The primary phenomena of the cells are the following: there is first a structureless substance present (cytoblastema), which is either contained in preexisting cells, or exists on the outside of these. Within this, cell-nuclei generally first arise—round or oval, spherical or flat corpuscles—which usually include one or two small dark points (nuclear-corpuscules). Around these cell-nuclei the cells are produced, and in such wise that they at first surround the nuclei closely. The cells expand by growth, and indeed by intussusception, and the same thing very commonly happens, for a certain period, in regard to the nuclei. When the cells have attained a certain stage of development, the nuclei generally disappear. With reference to the place at which the new cells arise in any tissue, the law is that they constantly appear where the nutritive fluid penetrates the tissue most immediately; therefore it is that the formation of new cells in the unorganized tissues only takes place at the points where they are in contact with the organized matter; in the completely organized tissues, again, where the blood is distributed to the whole of the texture, new cells are produced in the entire thickness of the tissue.

The process, by which the cells evolve themselves into the elementary formations of the individual tissues is very multifarious. The most remarkable differences are the following:—1. The elongation of the cell into a fibre, which probably takes place in consequence of one or more parts of the cell-wall increasing in a greater degree than the others. 2. The division into so many isolated fibres, of a cell elongated in different directions. 3. The blending of several simple or primary cells into one secondary cell.

Cartilage. The cartilages are distinguished among all the tissues of the human body, by containing the largest quantity of cytoblastema, which is also extremely consistent (fig. CXXXIV.) The quantity of cytoblastema, however, differs greatly in different cartilages. It is, for instance, much smaller than usual in the branchial cartilages of the larva of the frog (fig. CXXXV.). Here

Fig. CXXXIV.

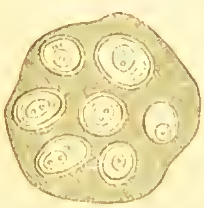


Fig. CXXXIV.—Cartilage; the nidus of the os ileum, but as yet without earthy deposit, from the fœtus of the sow.

the cells may be observed flattening one another as soon as they touch. The first formation, and the subsequent growth of cartilage, take place in such wise, that a cytoblastema is first produced, in which cells then form, whilst at the same time fresh cytoblastema arises, within which again cells are evolved as before, and so the process goes on. As the cartilage is without vessels at first, the formation of new cells only proceeds on the superficies of the substance, or, at all events, in the vicinity of this; in the situation, therefore, where the cartilage is in immediate contact with the nutritive matter. The production and growth of the cells of cartilage are exhibited in figure CXXXV. In the cytoblastema, on the surface of the cartilage at *a*, or between the new-formed cells at *b*, new cell-nuclei are arising. Around these, cells will by and by be formed, as at *c* and *d*, which still surround the nucleus intimately, and are very thin in the walls. These cells expand by growth, and their walls, at the same time, become thicker. The nuclei also grow in a very slight degree for a while. The cells contain now a clear fluid, now a granular precipitate, which generally first forms itself around the nucleus, as at *e*, fig. CXXXV. for example. In the old cells young cells occasionally arise—(Are these fat cells?) By and by cavities or canals (marrow-canals) are formed in the cartilages in a way which has not yet been investigated with sufficient care, through which vessels also take their course. If, after this epoch, any new cells are produced, we may presume that their evolution takes place not only from the surface of the cartilage, but also around these vascular cavities and canals; and, perhaps, it is from this circumstance, that after ossification, the cells are found disposed in laminæ, partly concentric around the cavity of the medullary canal, partly parallel with the surface of the cartilage. In the process of ossification, the earth is first deposited in the cytoblastema of the cartilage. The cells of the cartilage, at the same time, suffer a remarkable change, which seems to consist in this, that they become elongated in different directions into hollow processes or canals, and thus acquire a stellated appearance (stellated cells). The nuclei of the cells, during this process, are absorbed. At length, and finally, the cells themselves, and the canals proceeding from them, appear to become filled with calcareous earth.

Cellular tissue.—The cytoblastema of the cellular tissue is a structureless, gelatinous looking, transparent substance, not unlike the vitreous humour of the eye. Within this arise small round granular-looking cells, furnished with nuclei (fig. CXXXVI. *a*.) Here, too, the nucleus appears to be the part first formed, the cell being developed around it. As the cellular tissue contains blood-vessels, the evolution of new cells also proceeds through the entire substance of the tissue. The cells grow, but scarcely attain to twice the diameter

Fig. CXXXV.

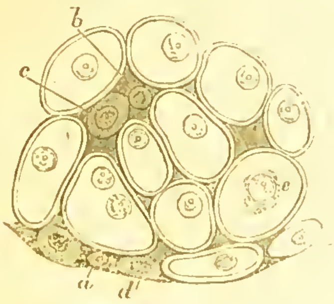


Fig. CXXXV. represents the branchial cartilage of a very young larva of the frog. The lower edge of the preparation is the natural limit of the cartilage.

of the nuclei they enclose; at a very early period, however, they begin to lengthen out in two opposite directions into fibres (fig. CXXXVI. *b*). The fibres then stretch on either hand into several branches (*c*, *d*,) and these, in their turn, proceed, dividing into still smaller fibres. This fibrillation of the branches, however, by and by proceeds backwards, towards the stem of the fibre arising immediately from the body of the cell; so that at a later period, instead of a single fibre, a bundle of isolated fibres is seen proceeding from either side of the body of the cell (fig. CXXXVI. *e*). Finally, the body of the cell itself also splits into fibres, and then, instead of a cell, we have a bundle of particular fibres, to which the nucleus of the former cell still continues attached. This process consists, therefore, in a kind of splitting up of a single cell into a multitude (perhaps of hollow) fibres. At a subsequent period, the nucleus is taken away, so that the fibres alone remain, and compose the filaments of the cellular tissue, as we find them in adults. It would appear, however, that they must suffer a chemical change, in addition to the changes in form, inasmuch as the cellular tissue at first affords no proper gelatine.

Muscle.—The researches of Valentin have shown that the muscles are composed of globules arranged in rows, like strings of beads, which then unite into a fibre,—the primary muscular fibre. The fibre thus evolved is a hollow cylinder, in the cavity of which cell-nuclei lie near to one another (fig. CXXXVII. *a*.) From this it becomes probable, that the globules which compose the fibre were

Fig. CXXXVI.

Fig. CXXXVI. — Various stages in the evolution of the cellular tissue of the fœtus of the sow; the stages are in the order of the letters of reference; *c* and *d* are mere varieties.

Fig. CXXXVII.

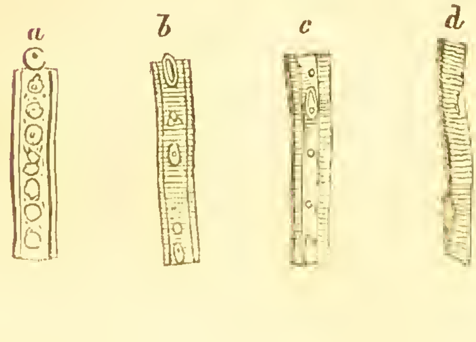


Fig. CXXXVII. *a*, *b*, *c*.—Different stages in the evolution of muscular fibre; *d*, a muscular bundle imperfectly developed, standing on its edge.

hollow,—were cells,—and that the nuclei, included in the cylinder, are the nuclei belonging to these primary cells. The earlier process of evolution, which I have not myself investigated, must therefore have been as follows:—the (hollow) globules or primary cells arranged themselves in a row, or coalesced into a cylinder, and then the septa, by which this cylinder must have been divided, underwent absorption. The nuclei are flat, and lie within the cylinder, not in its axis, but in its walls. This cylinder, rounded and closed at its ends,—this secondary muscular cell, grows continually, like a simple cell, but only in the direction of its length, for it either gains nothing in point of breadth, or it becomes actually thinner. The growth lengthwise, however, does not proceed from the ends only, but through the entire extent of the cylinder, as is obvious, from the fact of the nuclei, which at first lay close to one another, getting more and more distant, and even themselves elongating often in no inconsiderable degree. In this way, the muscular bundle *a*, (fig. CXXXVII.) is changed into the bundle *b*. At this period, the deposition of a new substance upon the inner surface of the parietes of the cylinder, or cellular membrane of the secondary muscular cell takes place, by which its wall is thickened (compare the fibre *c*, with the fibre *b*, fig. CXXXVII.) That the thickening of the wall here is no thickening of the cell-membrane itself, as it is in the case of cartilage, appears from this, that the nuclei are not forced inwards, towards the hollow of the cylinder, but outwards, and continue lying in front of the secondary deposition, as is seen in *d*, (fig. CXXXVII.). The secondary deposition in question goes on until the cylinder is completely filled. The deposited substance changes into very delicate fibres, which run in the direction of the length of the cylinder. These are the primary muscular fibres; together they constitute a bundle, and this is the primary muscular fasciculus, which is inclosed externally by a peculiar structureless wall—the cell-membrane of the secondary muscular cell. A process, in all respect, analogous, occurs according to Meyen, in the cells of the liber, or inner bark of vegetables. Here too, simple cells arise, which arrange themselves in rows, and by coalescing at the points where the cellular parietes are in contact, subsequent absorption of the septa being produced, change into a secondary cell, the wall of which increases in thickness by means of secondary deposition; the only thing wanting in the resemblance is, that this thickening should take place by means of longitudinal filaments.

Nerve.—The nerves appear to be formed after the same manner as the muscles, viz. by the fusion of a number of primary cells arranged in rows

Fig. CXXXVIII.

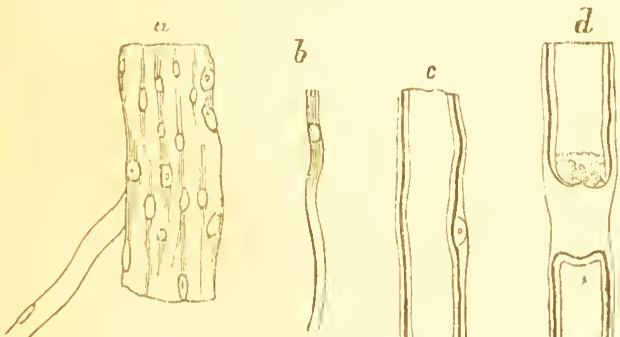


Fig. CXXXVIII.—Different stages in the development of nerve; *a* and *b*, of a very young fœtal sow; *c* and *d*, nervus vagus, from the cranium of a fœtal calf.

into a secondary cell. The primary nervous cell, however, has not yet been seen with perfect precision, by reason of the difficulty of distinguishing nervous cells whilst yet in their primary state, from the indifferent cells out of which entire organs are evolved. When first a nerve can be distinguished as such, it presents itself as a pale cord, with a coarse longitudinal fibrillation, and in this cord a multitude of nuclei are apparent (fig. CXXXVIII. *a*). It is easy to detach individual filaments from a cord of this kind, as the figure just referred to shows, in the interiors of which many nuclei are included, similar to those of the primitive muscular fasciculus, but at a greater distance from one another. The filaments are pale, granulated, and, (as appears by their farther development,) hollow. At this period, as in muscle, a secondary deposit takes place upon the inner aspect of the walls of the fibrils, or upon the inner aspect of the cell-membrane of the secondary nervous cell. This secondary deposit is a fatty white-coloured substance, and it is through this that the nerve acquires its opacity (fig. CXXXVIII. *b*). Superiorly, the fibril is still pale; inferiorly, the deposition of the white substance has occurred, and its effect, in rendering the fibril dark, is obvious. With the advance of the secondary deposit, the fibrils become so thick, that the double outline of their parietes comes into view, and they acquire a tubular appearance (fig. CXXXVIII. *c*). On the occurrence of this secondary deposit, the nuclei of the cells are generally absorbed; yet a few may still be found to remain for some time longer, when they are observed lying outwardly between the deposited substance and the cell-membrane (fig. CXXXVIII. *c*), as in the muscles. The remaining cavity of the secondary nervous cell appears to be filled with a pretty consistent substance, the *band* of Remak, and discovered by him. In the adult a nerve consequently consists, 1st, of an outer pale thin cell-membrane—the membrane of the original constituent cells, which becomes visible, when the white substance is destroyed by degrees, (*ex. gr.* fig. CXXXVIII. *d*); 2nd, of a white fatty substance, deposited on the inner aspect of the cell-membrane, and of greater or less thickness; 3rd, of a substance which is frequently firm or consistent, included within the cells, the *band* of Remak.

Along with these observations, and grounded upon them, Dr. Schwann has communicated to me some general views of the organic powers, which, however, in conformity with the plan of my work, I reserve for another place.

CONCLUDING REMARKS, RETROSPECTIVE AND PROSPECTIVE.

§ 87. After the exposition now given of the various particulars composing the processes of Generation and Development, it would be extremely interesting to trace back the appearances which we have observed to their elements. It cannot, in particular, be

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FIG. CXXXIX.

Fig. CXXXIX.—Cells from the granulations of the umbilical cord of the calf. They bear a striking resemblance to the cellular tissue of vegetables; nuclei are seen included in the several cells. After Breschet and Gluge (*Ann. des Sc. Nat.* t. viii. pl. 6, fig. 5).

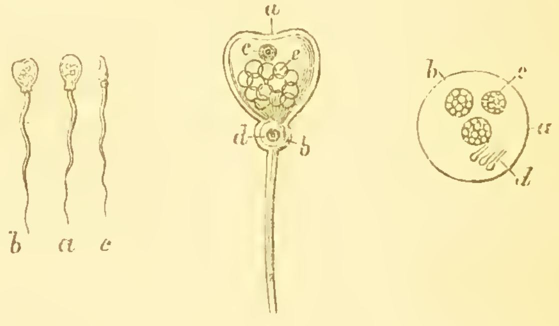
matter of doubt with the considerate observer, that the UNITY OF PLAN which forms the substratum as it were of the vast variety of phenomena occurring throughout creation, must also be cognizable here. The grand features, the chief results, would indeed present themselves simply, and might be announced in few words. But, as no organic process can be comprehended isolatedly in its essence; farther, as that which we in the sequence name with Goëthe, *primary* or *fundamental phenomenon*, cannot be shown from the empirical mode of contemplating an object in itself, but only with the assistance of another cognizant active power, viz. the mind; and finally, as our purpose is to give a THEORY OF ORGANIC LIFE, following from and based upon a careful observation of the elementary phenomena which make up its sum, it is evident that a *general view of generation*, or the THEORY OF GENERATION, can only be in place in our last Book, which comprises the General Physiology. At present, for example, it would be impossible for us, still unacquainted with the process of nutrition, to reduce the genesis of the human embryo to universal laws. A long series of preliminary queries, calculated to shed great light on the essence of the generative process, also requires to be answered; but these, too, upon the plan we have laid down, can only be taken into consideration in the GENERAL PHYSIOLOGY; among the number of queries now alluded to, the following, to select a few, present themselves: to determine the relations of the organism of the parents to the progeny; the hereditary transmission of corporeal forms, of mental aptitudes, and of liabilities to disease; the mode in which monstrosity originates; the numerical relations of the sexes; the resemblance in intimate structure of the objects composing both organic kingdoms, and so forth. These are all obviously subjects for our after consideration [171].

[171] Upon many of the relations just named, see the excellent article GENERATION, of Dr. Allen Thomson, in Todd's Cyclopædia of Anatomy and Physiology, I may be allowed to observe here, that I participate in the greatest degree in the thorough scepticism of the writer upon many points; for example, that the imagination of the mother produces any permanent bodily impression upon the progeny; that transitory states, such as that of intoxication, during the sexual act, can exert any influence on the corporeal or mental development of the being which is its result, &c.; by far the greater number of the data adduced in support of this popular belief will not bear investigation; and others admit of explanations very different from those usually given; it is otherwise, however, with regard to the transmission of the bodily and mental peculiarities which are stamped upon the parents; these, as we shall see at a future period, afford most important strong holds in framing a theory of generation, precisely as a general survey of the realm of organization teaches us to refer the genesis of organic bodies to universal and invariable laws.

[APPENDIX.

Organization of Spermatozoa. Addition to Annot. 13 *et seq. under* § 6.

In the 11th vol. of the *Nov. Act. Acad. C. L. Natur. Curios.* 4to. 1839, there is a paper by G. Valentin on the Spermatozoa of the Bear, in which the question of the organization and consequently of the truly animal nature of the seminal animalcule of this creature seems settled. The accompanying figures and description are copied from the paper.



Spermatozoa of the Bear.

In the left-hand figure, *a*, is the spermatozoon, seen from the upper surface; *b*, from the under surface; *c*, from the side. The middle figure is a view from the under surface of one of the spermatozoa, highly magnified, *a*, the anterior margin bent inwards; *b*, the distinct part of the body situated posteriorly; *c*, the mouth; *d*, the anus; *e*, the internal vesicles. The right-hand figure is one of the cysts of evolution; *a*, the outer envelope; *b*, the transparent contents; *c*, the vitelli; *d*, spermatozoa already formed.

The writer may be allowed to express doubts of the significance of the markings here set down as *mouth, anus*, &c. This amount of organization seems too much; were it all it is presumed to be here, indications of something of the same kind would not only be obvious elsewhere, but would probably be quite general.

In the same volume there is a paper by C. G. Carus on the *seminal tube* of the Sepia; in which he describes and figures a very complex organization, which as certainly belongs to an entozoon, probably a trichocephalus, as it does not belong to a spermatozoon. Carus had commissioned a friend near the sea shore to send him some of the seminal tubes of the Sepia for examination; the friend must have sent a bottleful of entozoa instead. An excellent notice upon the seminal tubes of Sepiæ may be seen in the *Ann. des Sciences Naturelles*, No. for April, 1840, by Mr. Milne Edwards. These tubes are undoubtedly the cysts in which spermatozoa appear to be universally developed, in a persistent state. The writer quoted compares them very aptly to the pollen-capsules of plants, and proposes the title *Spermatophores* for their designation. R. W.]

END OF PART I.

LONDON:
GILBERT & RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.